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T. COMMERFORD MARTIN, JOSEPH WETZLER, Associate Editors.
G. H. STOCKBRIDGE, Assoc. Editor Patent Department.
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CONTENTS.

ILLUSTRATED ARTICLES: PAGE.
Schlesinger's Electric Locomotive Motors ... 88
Daft Electric Railway Motors for Pittsburgh ... 89
Sir Wm. Thomson's New Standard Measuring Instruments ... 89
The Electro-Engraving Machine ... 90
Electric Welding by Means of the Arc ... 91
Schwedoff's Thermo-Magnetic Motor Experiment ... 92
The Bentley-Knight Electric Railway at Allegheny City, Pa. ... 92
Some Researches in Thermo Electricity ... 93
Alternating Current Electric Motors ... 95
The Hussey Re-Heater For Electric Light Plants ... 97

NEW BOOKS:
"Thermo-Dynamics" ... 88

CORRESPONDENCE:
Effects of Heating Platinum Wire ... 94

EDITORIAL PARAGRAPHS ... 87

MISCELLANEOUS: PAGE
Wire Space in Large Buildings ... 88
The Price of the Factor of Safety in Lightning Rods ... 88
On the Effect of Magnetization on the Thermo-Electrical Properties of Bismuth ... 92
Series Glow Lamps ... 92
Nickel-Plating Solution ... 94
1874-1888 ... 97

SPECIAL CORRESPONDENCE:
New York Notes ... 98
New England Notes ... 98
Philadelphia Notes ... 98
Western Notes ... 98
English Notes ... 99

DEPARTMENTS:
The Telegraph ... 99
The Telephone ... 99
The Electric Light ... 99
Applications of Power ... 100
Personals ... 100
Miscellaneous Notes ... 100
Business Notices ... 100
Our Illustrated Record of Electrical Patents ... 100

Fourteen Years in the Field. IT happens that the meeting of the National Electric Light Association at Pittsburgh, in session as we go to press, coincides with the beginning of the fifteenth year of this journal. We have thus felt that a little sketch of the growth of the paper during that period, as an institution, would be timely, and a brief article of the kind will be found on another page. A distinguished speaker, Mr. Chauncey M. Depew, said last week that the main criticism against newspapers was that they prevented men from thinking, by furnishing them with ready-made opinions. That animadversion does not apply, however, against the technical press, whose one mission is to set men thinking for themselves, so that by their professional perfection, and by their inventions and improvements, the arts and sciences may be advanced. Such, at least, has been the main aim and leading idea of THE ELECTRICAL WORLD, and in this way the paper has kept pace with, and promoted, the scientific and industrial interests of electricity.

An Original Morse Sketch. AT the last meeting of the New York Electrical Society there was exhibited an original sketch by Prof. Morse, and bearing his signature, dated 1846, which depicted "an improved bascule" in connection with his telegraph system. The sketch was handsomely framed and was presented by Mr. Jas. D. Reid to the Franklin Institute on behalf of the New York Electrical Society. The sketch, which was made in pencil, shows to a marked degree the artistic instincts of Prof. Morse, as all the lines indicating circuits are drawn in graceful curves. The sketch was examined with great interest by the members.

Thermo-Electricity. MR. E. G. ACHESON, whose thermo-electric generators, we have already described, treats in this issue of his experiments in this branch, in a manner which brings us to the consideration of the very intimate relation existing betwen the forces of nature. The hypotheses which Mr. Acheson advances to account for the phenomena observed, are most interesting, and the basis of them is his assumption that a ray of heat may, under certain conditions, be surrounded throughout its length, by closed lines of magnetic force. Looked at in another way it might be said that, according to Mr. Acheson, a ray of heat may be "polarized" by the influence of magnetism and thus brought into a state of potential energy, as distinguished from the latent.

Thermo-Dynamics and Thermo-Electricity. ON the next page we review a book, the study of which cannot fail to give the student correct ideas as to the co-relation between heat and work. At this time especially, when the solution of the problem of the conversion of heat into electricity, and into power through the medium of electricity, is so prominent a one, those who are about to enter upon similar investigations must, in order to be successful, be well versed in the laws relating to the conversion of heat into work. In fact, by the application of the laws of thermo-dynamics, we may determine at once the efficiency of any type of apparatus for converting heat into work, and thus we may, without going to the expense of constructing an apparatus, determine within close limits the value of any particular device, when its conditions of work are given.

Wiring Buildings. IN another column Mr. Healy draws attention to the fact that in the erection of large buildings, such as are now very common, arrangements must be made to place the wires suitably for the various services which modern progress places at the service of the occupants of the building. He remarks truly, that the different requirements of each tenant cannot be foreseen, and hence provision must be made to provide them with whatever they may require without disturbing the wires of any other service. The manner in which this can best be accomplished appears to Mr. Healy to be an open conduit, so that the wires can be got at directly and inspected at every point of their course. These conduits might be made ornamental, and would avoid the difficulty experienced with closed pipes and the like. If we mistake not, something of the kind has been adopted in the electrical department of the city of Philadelphia.

Electric Light Fuses. THE discussion on a recent paper on fuses read by Mr. Cockburn brought out a diversity of opinion regarding not only the material of which fuses should be made, but also the manner in which they should be applied. Thus it was shown that the introduction of fuses in a promiscuous manner may defeat the very object for which they are intended, and unless the joint at the insertion of the fuse is a perfect one, its presence is a direct menace to the safety of the circuit. Attention was also drawn to the fact that platinum is a decidedly valuable feature as a material for the construction of electric light fuses, but its excessive cost evidently prevents its employment for that purpose. Again, as to the material out of which the fuse-box should be constructed, one well-known English electrician objected decidedly to the insurance rules, which require the placing of such fuses upon slate. He averred that slate was a bad insulator, and he was corroborated in that statement by others who claimed that that material could only be made a good insulator by immersion in melted paraffin.

A Vigorous Pamphlet Warfare. THE sensation of the week has been the publication by the Edison Electric Light Co. of a most trenchant pamphlet, dealing with leading questions connected with the incandescent light at the present time. The pamphlet contains many signs of having been prepared with great care, which extended even to the choice of words and phrases. Aside from the piquancy of the controversy on its broader public grounds, there is much of interest to be found in the manner in which issue is directly joined as to the relative economy and safety of the direct and alternating systems. The pamphlet contains, for example, a diagram giving figures of both systems for a plant of 8,400 lamps at Minneapolis, and bringing out a marked difference in favor of the direct three-wire system. Where the challenge has been so boldly and flatly given, it is most likely that it will be taken up. The "Warning," with its five "Cautions," is certainly as interesting a publication as we have seen in many a long day, and the demand for it bids fair to exhaust the very large editions which rumor says have been printed and are now being distributed.

Economy in Station Operation. IN several instances where two electric light stations are operated by one company in our large cities, trunk wires combine them so that one station may take the load of the other during the time when the demand for current is small, and thus the operating expenses of one station may be considerably reduced. This system has now been adopted in Berlin by the electric light company, so that only one dynamo station is at work during most of the day, and during the latter part of the night, at which periods the demand is small. The other station, on the other hand, is only working during the early hours of the evening, so that a considerable saving in the attendance required at the station is effected. This plan has the advantage that duplicate machinery need only be provided at one station, as there is but little likelihood of a breakdown occurring simultaneously at each. But the disadvantage of the system consists in the fact that a considerable amount of capital is lying idle during a large part of the day, and though the operating expenses are reduced, the fixed charges in other directions remain the same. It is still to be seen, however, whether by the aid of the storage battery a continuous operation of the station during practically 24 hours of the day will not show a better income than the arrangement just described. We think it will.

Weighing the Electric Current. AFTER years of study on the question of devising electric measuring instruments which shall be permanent in their character, Sir Wm, Thomson has at last determined on the oft-presented plan of opposing the action of the electrical current by gravity, so that all the errors due to the employment of permanent magnets, iron, springs, etc., are avoided. Although they have long been suggested, the great difficulty of constructing instruments of this kind has been to devise a balancing beam which should provide means of conducting the current to and from the balance without impairing its buoyancy. The manner in which this has been accomplished by Sir Wm. Thomson is most ingenious, but it seems to us that the same object might be attained by the employment of what is known as the torsion balance principle in which no pivots or knife edges are employed and in which the stretched wire forms the centre on which the balance turns. This wire might easily be adapted to carry the current to the weighing coils, and would, it strikes us, simplify the construction of the instrument. While the instruments of Sir Wm. Thomson are no doubt ingenious and permanent in their indications, some of them are hardly adapted to general use, as they require auxiliary means of obtaining the value of the quantity sought for. But, aside from this, the principle employed leaves little room for the creeping in of errors, and their indications are probably as constant as can be obtained from any instrument designed for the same purpose.

Alternating Current Motors. IT was not to be supposed that those interested in the distribution of current by the alternating system would overlook the fact that one of the chief revenues of every electric light station would ultimately be derived from electric power distribution; and as a natural sequence, the efforts of many have of late been turned in the direction of supplying alternating current motors. The interest in the subject is well demonstrated by the very lively discussion of Dr. Duncan's able paper, read before the American Institute of Electrical Engineers. Considering, first, Dr. Duncan's paper, it is evident that of the various types of alternating current motors, which he classified under four heads, some are better adapted to everyday work than others, and he has done well in pointing out what theory shows to be the best directions in which to work. Regarding the construction of alternating current motors, the discussion brought out the very interesting fact that the lamination of the pole pieces to avoid eddy currents, though at first sight an expensive process, is by no means an obstacle to such construction. In fact, one speaker went so far even as to assert that laminated field magnets, within certain limits of sizes, were more economical than the solid. It was also brought out during the discussion, that experiments are under way looking to the adoption of the alternating current motor for street railway work, and the query was not unnaturally advanced, what would the gain be by using alternating current motors, when even at the present time electric railways were being operated at high potential with very efficient continuous current motors. We must ourselves confess, that the doubt raised as to the superiority of the alternating over the continuous current for this purpose is a reasonable one. The conclusion which Dr. Duncan arrives at as to the best method of applying the alternating current to the driving of motors, is one which is indeed novel. Reasoning from the result of his investigations, that the alternate current dynamo of to-day with field magnets excited by continuous current would make a most efficient motor, he suggests that the excitation of the field magnets could probably be most economically obtained by a continuous current supplied from a central station by a separate circuit and dynamo. He recognizes the fact that part of the alternating current could be commutated for the purpose of supplying the field, but he looks with little favor on this method of excitation. Dr. Duncan, however, does not lose sight of the fact, that an alternating motor such as he proposes, will not start itself and hence he suggests a plan by which the motor is temporarily converted into a continuous current motor at the start, and then converted into an alternating one. While Dr. Duncan seems to think that such a construction might be made simple, it would appear to involve elements which would make the adoption of such a motor somewhat doubtful. For, however efficient an apparatus may be, the conditions under which it is operated are no less factors of importance that enter into the problem of actual practical work. As stated above, the discussion brought out the fact that a number are busy on this problem, and the motor described during the discussion by Lieut. Patten is a very ingenious adaptation of the principle pointed out by Prof. Elihu Thomson. With the activity now manifested in this field, it is likely that we will not have long to wait for the alternating current motor.

NEW BOOKS.

THERMO-DYNAMICS. By De Volson Wood, C. E., M. A., Professor of Engineering in Stevens Institute of Technology, Hoboken, N. J. Published by the Author. 5 × 7, 235 pp. Price, $2.

Undoubtedly Rankine was a master in the science of thermo-dynamics, and he who has thoroughly understood his treatise on the subject may be said to be adequately and efficiently posted about the mechanical theory of heat, and the physical and mathematical laws of heat in its molecular motion as a form of energy. But what appeared as easy steps to the master have proved very difficult ones to the student, and but few can hope to follow him, appreciatively throughout, in his original presentation. Thus it has come about that attempts have been repeatedly made to simplify Rankine's teachings, almost invariably at an expense of accuracy and often even of truth itself.

It is, therefore, with unfeigned gratification that we hail Prof. Wood's treatise and commend it as a correct, detailed and yet comparatively simple presentation of the science of thermo-dynamics, following closely the spirit of Rankine's work, and explaining, lucidly and concisely, steps and results which Rankine puts forward, often with but little explanation. To the student of Rankine's thermo-dynamics it will be an invaluable aid, but we question whether most students will feel the need of reading Rankine after having mastered Prof. Wood's treatise. After absorbing the contents of Prof. Wood's book they will find themselves in possession of all they need to know for any practical purpose on the subject of heat as a form of energy in practical mechanics.

The examples and exercises which are met with every few pages and which are a distinctive and original feature of this work, distinguishing it from any other on the same subject, well serve to illustrate and still further elucidate and enforce, by application, the lessons of the text. The insertion of these practical exercises would, alone, stamp the book as a contribution of rare value, did not the presentation of the subject-matter in so lucid and correct a manner, and in conformity with the spirit of Rankine, of itself entitle the production to the same verdict.

In this, the nascent period of thermo-electricity, when many are beginning to become interested in this enticing field of investigation, electricians desirous of being grounded in the mathematical theory of heat can do no better than study Prof. Wood's treatise. It may save them costly mistakes, and its study is sure to be fraught with interest, pleasure and profit.

Schlesinger Electric Locomotive Motor.

The work of Mr. W. M. Schlesinger, the electrician of the Union Electric Company, in the field of electric traction has attracted considerable attention, and we are glad to be able to give further descriptions and illustrations of his work.

The motor represented by Figs. 1 and 2 is capable of giving 35 h. p., and is designed especially for locomotives having to haul heavy loads. It is 27½ inches broad, 43½ inches long and 22 inches high, and weighs, with countershaft and gear, 1,500 pounds.

The armature is of the Siemens drum type, 9½ inches in diameter, and has a core 10½ inches long.

The wires are wound within troughs fastened to the core of the armature, and are thus prevented from being displaced either to one side or to the other by the pull exerted by the magnets on them. This pull with a motor varies from one side to the other as the direction the motor runs in as altered, and tends not only to loosen the wires, but also, by causing them to move, gradually to destroy the insulation.

The armature makes about 1,000 revolutions, the countershaft about 400. The bearings of the latter are part of the same frame in which the two armature bearings are cast. This keeps the two shafts parallel under all conditions and insures an easy running of the gears, even with the most trying alteration in the load. After six months' running, the teeth of the pinion showed a wear of $\frac{1}{64}$ of an inch; *i. e.*, about $\frac{1}{128}$ of an inch on each side of the tooth.

The 32 part commutator is placed outside the bearings, and is constructed in such a manner that it can be taken off and replaced by a new one within an hour and a half,

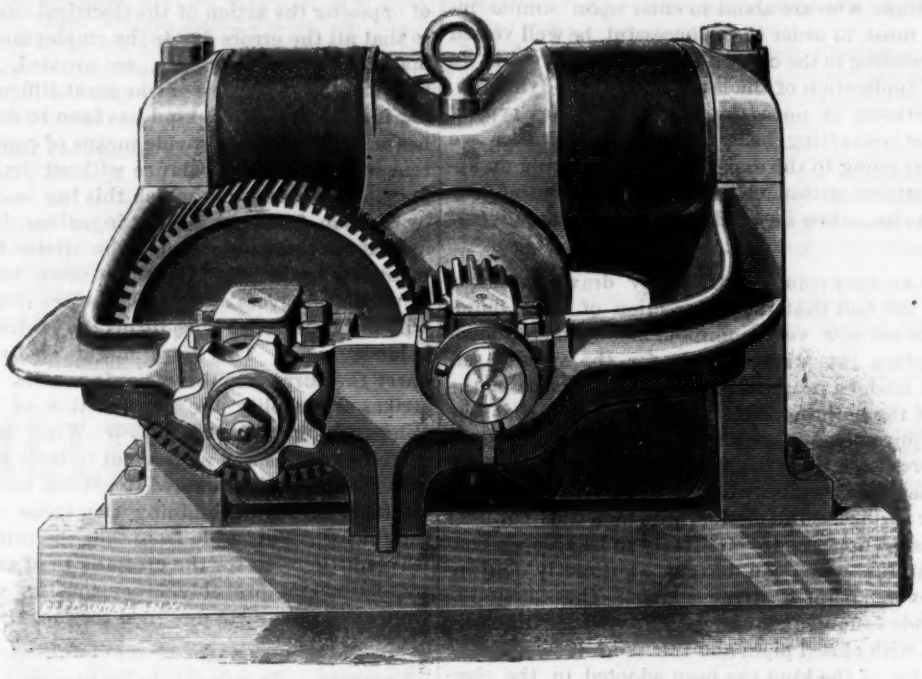


FIG. 1.—SCHLESINGER MOTOR FOR LOCOMOTIVE WORK.

it being unnecessary to disturb any of the other parts of the machine, or to make any electrical connection otherwise than to solder the wires into grooves in the commutator bars. As all these wires are so arranged that they can be placed in no other groove than the one to which they belong, it requires no electrical knowledge or training to accomplish this. The great advantage of this method can be seen when comparing the time and work required for the exchange of an old commutator for a new one on this motor, with that required for a motor having the commutator inside the bearings. With the latter it is not only necessary to take the motor more or less apart, but also to remove it from the truck or car to which it is attached; furthermore, in most cases (nearly always when the Siemens type of armature is employed) the front cap has to be removed, and it requires a thoroughly trained workman or electrician to replace the wires. All this requires from 8 to 24 hours time and about 3 men. Having the commutator outside the bearing, it has the further advantage of allowing at all times an easy inspection of it and the brushes, and facilitates the proper setting or adjusting of the latter.

One of these motors has been running for the last six months in the Lykens Valley Coal Company's mine at Lykens, Pa., hauling daily about 500 tons gross weight over a road 6,300 feet long. This load is gradually being increased, and it is expected to haul about 1,000 to 1,300 tons gross weight daily. Some of the work this motor has accomplished was to haul a train weighing about 150 tons, consisting of 31 cars and 880 feet long, round two curves, the one having a radius of 20 feet, and the other 30 feet, and the distance between them being 180 feet. This same train had afterwards to be started while standing partly on a level and partly (100 feet) on an up grade of 15 inches in 100 feet. The average number of cars hauled by this motor in one trip varies between 10 and 20, these cars being loaded partly with coal and partly with rock or slate. A second motor of the same type will in a short time be in operation in another part of the mine, where it will have to haul daily 300 loaded cars, representing a gross weight of about 1,500 tons, and 300 empty cars weighing about 450 tons, so that the total load of this motor will be nearly 2,000 tons.

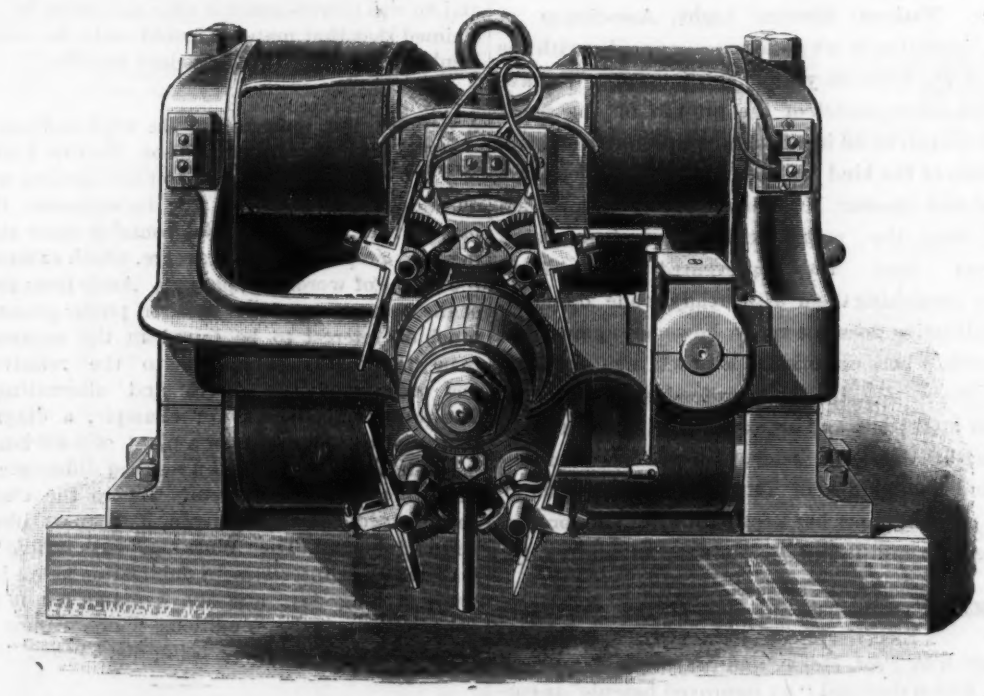


FIG. 2.—SCHLESINGER MOTOR FOR LOCOMOTIVE WORK.

Wire Space in Large Buildings.

BY C. L. HEALY.

I would like to call the attention of architects to their utter disregard to arranging wire space, or providing for the accommodation of the tenants of the large modern office buildings with electric facilities, without disfiguring the walls, ceilings and moldings.

Nearly all such offices have a call box or telephone. Brokers have these with "tickers" and Morse wires, and some 30 or 40 wires are needed from several different companies. We cannot wire these offices as we would for electric lighting, as it is impossible for the owner to know what class of tenants will occupy his rooms. Hence, we must make such provision that each office on each floor can be wired for any service at any time.

To do this the most practicable way would be to provide large flues in the walls, to connect each floor with the basement or roof, each floor to have a conduit running along the floor or the hallway or wall, with a cover, so that it could be removed when any new wires were to be run or taken out. These conduits should connect each room on that floor with an opening under the floor so that all wires could be put out of sight. Iron pipes run in this way have been tried but have failed, as a separate one for each company cannot be laid, and where one is used for all, after a few wires or cables have been drawn in, any attempt to pull in others simply serves to entangle the whole lot, the tendency being to work down around all that are already in the pipe. Thus it will be seen that only some system of open conduit is of any value for the daily requirements. With the exception of one or two buildings put up in this city, no thought has been given to individual office wiring for the numerous electric companies whose service is the part and parcel of the business of the occupants of the offices. Here is a serious defect which must very soon be remedied and guarded against.

The Price of the Factor of Safety in Lightning Rods.

In a paper recently read before the Physical Society, by Prof. S. P. Thompson, it is shown upon certain assumptions that the factor of safety against fusion varies as total cost $\times \frac{f\,s}{\rho\,d\,l^2\,k}$, where f = temperature of fusion of material above atmosphere, s = specific thermal capacity, ρ = specific electric resistance, d = density, k = cost in pence per lb., l = length of the conductor. If the total cost and length are supposed to be given, the factor of safety $= \frac{f\,s}{\rho\,d\,k}$. Of the common metals, neglecting self-induction, iron has the greatest factor of safety, being more than four times that of copper. Such being the case, the author thinks it desirable that the report of the Lightning Rod Conference be reconsidered.

Daft Electric Railway Motors for Pittsburgh.

The illustrations, Figs. 1 and 2, of which the following is a description, show two of five independent electric railway motors, which are the most powerful of their kind that have yet appeared in the arena of electrical propulsion for street railway work. They are built for the Pittsburgh, Knoxville & St. Clair Street Railway, whose route lies principally in the last-named township and involves difficulties enough to merit specific enumeration.

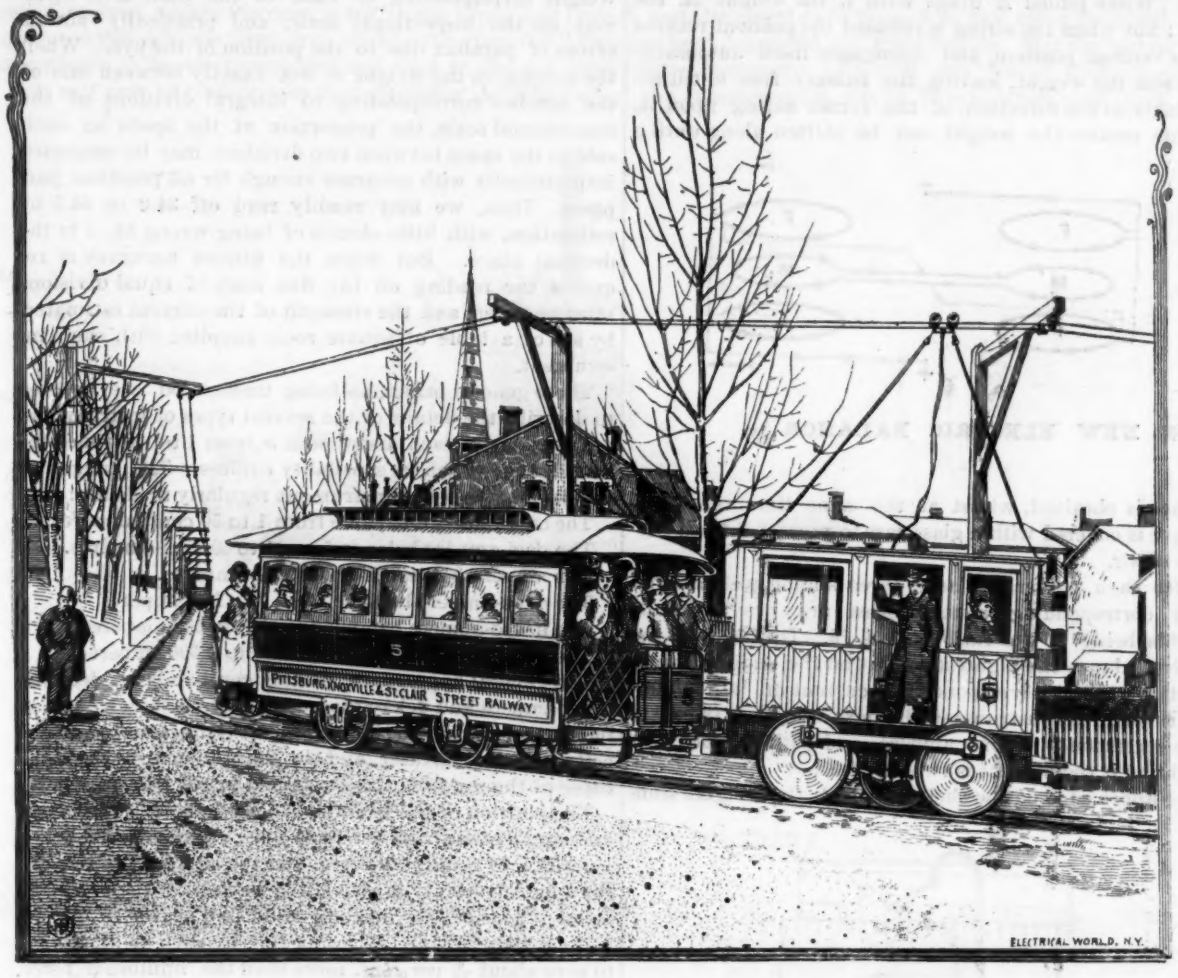


FIG. 1.—DAFT ELECTRIC RAILWAY, PITTSBURGH, PA.

Its total length is 1¼ miles, embracing gradients of all degrees, except "level," from 16 per cent. downwards, and 10 curves with a minimum radius of 35 feet. The gauge of track is, for this region, the unusual one of 5 feet 2½ inches. Two methods of conduction are resorted to, viz.: overhead wires with trolleys and an underground conductor in a conduit. The length of the latter is 800 feet and its general design—as well as that of the overhead conductor and trolley—is sufficiently familiar to dispense with the necessity of a description.

The motors themselves, however, are of special design, and even a detailed account of them is not likely to lack in interest. Their finished weight is 6 tons, their wheel-base 5 feet and their tractive capability 35 h. p. While they exhibit no marked departure from the ruling principle of Mr. Daft's design, their unusual size and the severity of the work they must perform has introduced several appliances, both of necessity and for convenience. The most notable of these is the movable sprocket-wheel that engages with a perforated band or rack, secured to the crossties between the rails, and parallel with them upon the steep ascents, to obtain the necessary adhesion when the track is icy or slippery with mud. The sprocket-wheel shaft is connected with the driving-axle of the motor by an endless chain, and is lowered into, or raised from, the rack at pleasure by a wheel and screw upon the footboard.

Another device is an electric brake, the theory of which is as follows: When the motor descends a gradient solely under the influence of gravity, the current from the dynamo-generator being shut off, its armature, revolved by the motion of descent, changes its function and becomes itself a generator, delivering its current oppositely to that it normally receives as a motor, and this is passed through variable resistances which have the same effect upon the current as a contracted pipe upon a flow of water and control the motion of the armature—and consequently of the vehicle—with a promptitude, precision, and effectiveness that no mechanical brake can, it would seem, rival.

Each motor, however, is also fitted with a powerful toggle joint brake, both as a reserve and for use when moving the motor without current.

The illustrations show a motor and loaded car, in one case upon a 12½ per cent. gradient, and in the other upon a curve of 88 feet radius; neither of which has, it is claimed, proved a difficult obstacle to deal with. The motors were built under a guaranty to surmount the maximum gradient, 16 per cent., towing a loaded tram-car at a speed of not less than 3 miles per hour, or, as was calculated, to exert a tractive effort of 3,500 pounds. While they are not yet in regular service, owing to the incomplete condition of the track, they have nevertheless been put through a variety of tests, some of which are as follows:

On one occasion a motor, disabled by an accident and still coupled to a loaded tram-car, was taken in tow by another motor and hauled, at the usual speed, up a 12½ per cent. gradient without any observable effect whatever upon the towing motor or the dynamo-generator.

Again, a motor with loaded car surmounted, it is stated, a 13 per cent. gradient at a speed of 6 miles per hour, and what is more remarkable, did this—the road being clean and dry—without recourse to the sprocket-wheel for adhesion. An unloaded motor performed the same feat at a speed of 8 miles per hour.

Several of the motors have, at different times, hauled a car loaded with 75 passengers up a gradient of 15 per cent. at speeds much above the contract limit, without the slightest difficulty.

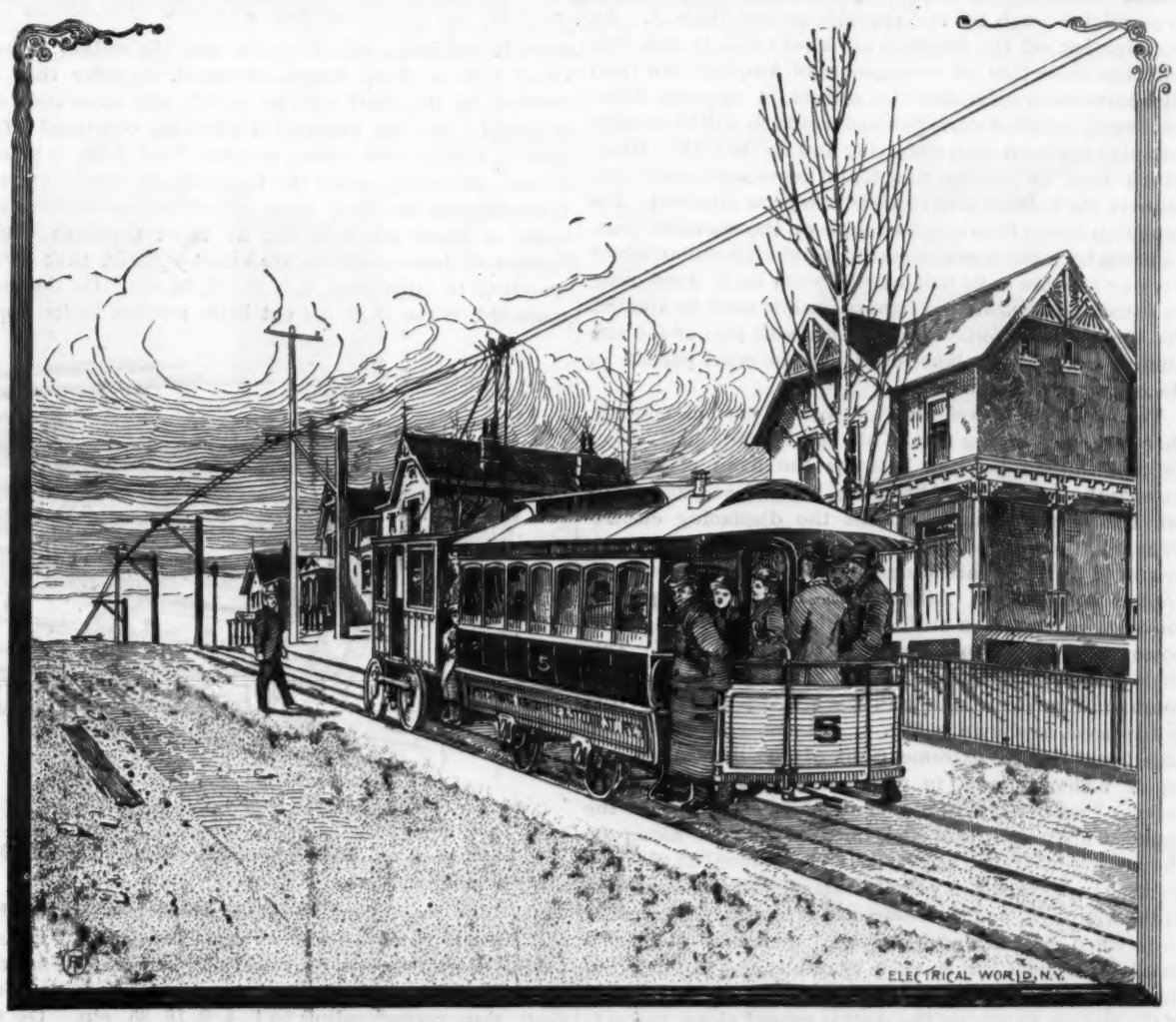


FIG. 2.—DAFT ELECTRIC RAILWAY, PITTSBURGH, PA.

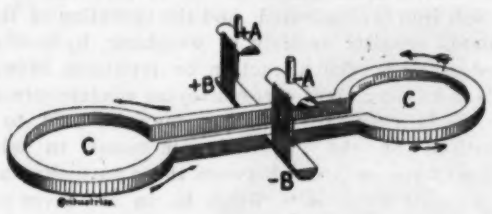
Sir Wm. Thomson's New Standard Electrical Measuring Instruments.

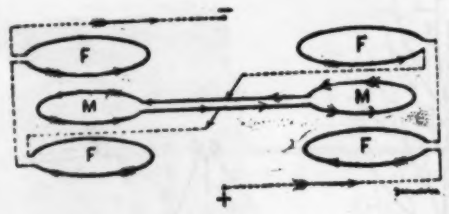
For the last six years, Sir William Thomson has been engaged in developing and perfecting a complete series of instruments for the measurement of electric currents. Beginning with the now well known graded galvanometers, he has finally accomplished the task of providing a connected group of instruments, which may be broadly classified into three divisions: (1) Standard direct reading electric current balances; (2) magnetostatic galvanometers or lamp counters; (3) marine and engine room voltmeters. The standard direct reading electric current balances are standard instruments, in which every source of possible error arising from the use of permanent magnets or soft iron is eliminated, and the operation of these instruments consists entirely in weighing, by means of standard weights, the attraction or repulsion between movable and fixed coils of wire conveying electric currents. These standard current balances may be said to be modifications of the electro-dynamometer in which the mutual force or stress between these mutually influencing portions of the same circuit is, in any given position, proportional to the square of the strength of the current traversing the two portions of the circuit. In Sir William Thomson's standard instrument this stress is measured by comparing it with or balancing it against the weight of certain standard masses; in other words, the electro-dynamic stress is compared with the gravitation stress on a given mass.

The great difficulty which has hitherto presented itself to all who have attempted to design instruments on the electro-dynamometer principle for any but very small currents has been that of getting the current into and out of the movable conductor. The device on which most experimentalists have fallen back, says Dr. J. A. Fleming in *Industries*, is that adopted by Ampère himself, viz., to use mercury cups as a means of constructing a flexible and conducting joint. The use of mercury is open to many objections. The surface gradually becomes oxidized, the cups must be filled and emptied each time, the instrument has to be transported, and the joint with impure mercury is by no means exceedingly flexible. The great achievement in these instruments has been, first, the invention of a joint or electric coupling which is excessively flexible, and at the same time capable of being constructed so as to carry with safety any current desired. This has been accomplished by the introduction of a device which may be called a metallic ligament.

The general principle of its construction, and the mode of rendering a circuit freely movable, yet accessible to a large current, may be described as follows: Let *A A*, Fig. 2, be a pair of semi-cylindrical fixed trunnions, which are carried on some form of supporting frame, and held with the flat sides downwards. Let *B B* be two similar trunnions, which project out from the sides of two strips, connecting together a pair of rings *C C*. The pair of rings and the connecting strips constitute the circuit which is to be rendered movable. A current entering by the trunnion

+ *B* flows round the two halves of the circuit, as shown by the arrows, and emerges at the trunnion — *B*. This is the case in all but the kilo and hekto-ampère balances, in which the current divides round the ring. To the upper surface of the upper trunnion are soldered a very large number of exceedingly fine copper wires (No. 60 B. W. G.), which are laid close together. These wires are also soldered to the under surface of the lower trunnion. The movable circuit *C C* thus hangs from the upper trunnion by two ligaments, which appear like thin strips, but which are really composed of an immense number of very fine wires. In Fig. 2 these ligaments are intentionally drawn much longer in proportion





FIGS. 2 AND 3.—SIR WM. THOMSON'S NEW ELECTRIC BALANCE

to the rest of the figure than they really are in the instrument, the object being to render the mode of suspension clear. This method of suspension enables the conductor *C C* to vibrate freely like a balance by a motion which is partly a bending of the flexible ligaments, and partly a sort of rolling and unrolling of the lower trunnion on the ligament attached to it. By this ingenious method not only can a heavy copper conducting circuit of the shape shown be suspended as freely as the beam of a good balance, but at the same time a very large current density can be permitted in the flexible ligament, since its great radiating surface, and the freedom with which heat is taken out of it by conduction into the mass of the trunnions, allows a proportionately very large current to be transmitted. If, then, the trunnions *A* and *B* are the electrodes, the method above described affords the means of passing a very large current into the circuit *C C*, which yet at the same time retains within certain narrow limits great freedom of movement.

Let such a suspended conductor be arranged so as to have a circular conducting circuit of annular form, briefly called an ampère ring, placed above and below each of the movable rings of the balanced arm. Let the connections be made as shown diagrammatically in Fig. 3, in which it will be seen that the current entering by the + electrode flows in series through all four fixed ampère rings *F*, and in parallel through the two movable ampère rings *M*. An examination of the direction of current flow in each ring will then show that, in consequence of Ampère's law (parallel currents in same direction attract, in opposite direction repel), forces of attraction and repulsion will be brought into play between each fixed ring and the movable rings, which tend to lift one ring *M* and depress the other, and tilt over the balance arm to which they are attached. The ampèrian forces thus exert a couple on the movable part. To bring back the movable part to its initial position, which we may suppose to be half way between each fixed ring, an equal and opposite mechanical couple must be applied. We shall in what follows call the movable part of the conducting circuit the balance coils, and the other portion of the circuit the fixed coils.

The operation of weighing an electric current consists, therefore, in bringing first of all the balance coils, into a definite sighted position between the fixed coils, then passing the current, and bringing back the balance coils into the sighted position against the displacing electrodynamic forces by applying to the balanced part a couple produced by a standard weight. The restoring couple is applied as follows: Attached to the balanced part or movable portion is a stiff metal bar, turned up at the bottom edge so as to form a sort of long shelf. This shelf or tray extends the whole length of the movable beam, and moves or tilts with it when the balanced part is displaced, as shown in Fig. 1. At one end of the balanced part, at the extreme right of our illustration, is a small V-shaped tray, in which a weight is placed. A standard weight is then placed at the opposite end of the shelf. This weight is of such form as to slide along the shelf easily, as shown in Fig. 4. When placed at the zero position on the shelf, it exactly balances the counterpoise in the V-trough, and the balance part should be in equilibrium when no current is passing. If it is not so, then a small adjustment can be made by means of a metal flag on the beam Fig. 1, similar to that on a gravimetric balance. If the sliding weight on the shelf is moved along towards the middle, the equilibrium is disturbed and a couple brought to bear upon the balanced part, which is proportional to the displacement of the sliding weight from its zero position. If a current is passed through the circuit, and the sliding weight displaced so as to restore the balance to its sighted position, the current strength is proportional to the square root of the distance by which the sliding weight has to be shifted in order to restore equilibrium.

The shifting of this weight is performed by a very ingenious piece of mechanism, which will be understood from the enlarged view Fig. 4. On the base board of the instrument, and just underneath the shelf on which the weight slides, is placed a little metal block, which carries a stout vertical wire extending a little above the shelf carrying a pendant wire, which hangs down through a notch in the weight which slides on the shelf. This block, carrying the pendent, is pulled along the railway by a silk cord. When pulled it drags with it the weight on the shelf; but when the string is released the pendent returns to its vertical position and disengages itself automatically from the weight, leaving the balance free to tilt accordingly to the direction of the forces acting upon it. By this means the weight can be shifted along until a balance is obtained, whilst at the same time the whole balance is covered with a glass case to protect it from currents of air.

With each current balance three sliding weights and three corresponding counterpoises are provided, the weights being in the ratio of 1, 4, 16. Thus if with the ampère-balance the lightest weight on the sliding tray in a certain position corresponds to a current of half an ampère through the instrument, the next weight at the same place corresponds to one ampère, and with the heaviest weight on it the current is two ampères.

The upper edge of the shelf on which the weights slide

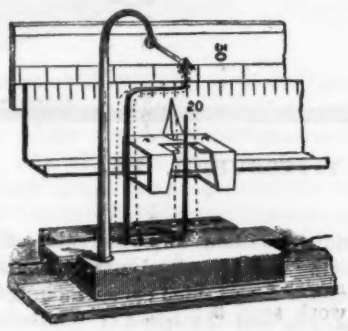


FIG. 4.

is graduated into equal divisions, and the weight is provided with a sharp tongue of metal, in order that its position on the shelf may be readily and accurately determined. For the purpose of avoiding continual reference to square root tables, another fixed scale is placed behind the shelf, called the inspectional scale. On the upper edge of the shelf, along which the graduations are made, a small notch is cut at those divisions whose numerical denominations are exact squares, thus corresponding to divisions 1, 4, 9, 16, 25, 36, etc. On the scale engraved on the shelf are cut little notches in its upper edge. The inspectional scale is fixed close behind this, and yet not touching, and at those points on it exactly behind the notches are engraved numbers which are twice the square roots of the corresponding numbers on the shelf, thus corresponding to 1, 4, 9, 16, 25, etc. On the shelf the numbers 2, 4, 6, 8, etc., are engraved on the inspectional scale.

Since the current passing through the balance when the equilibrium is obtained with a given weight is proportional to the square root of the couple due to this weight upon the balance, it follows that the current strength when equilibrium is obtained is proportional to the product of the square roots of the weight used, and of the distance of this weight from its zero position; but the inspectional scale is so graduated as to show at a glance the square root of the distance of the weight from its zero position, and hence the numbers on the inspectional scale indicate half ampères, ampères, or double ampères, according to the weight used. The fixed inspectional scale shows approximately enough for many purposes the strength of the current; the notches in the top of the aluminium sliding scale or shelf show the precise position of the weight corresponding to each of the numbered divisions on the inspectional scale, and practically annuls errors of parallax due to the position of the eye. When the pointer on the weight is not exactly between one of the notches corresponding to integral divisions of the inspectional scale, the proportion of the space on each side to the space between two divisions may be estimated inspectionally with accuracy enough for all practical purposes. Thus, we may readily read off 34.2 or 34.7 by estimation, with little chance of being wrong by .1 in the decimal place. But when the utmost accuracy is required, the reading on the fine scale of equal divisions must be taken, and the strength of the current estimated by aid of a table of square roots supplied with each instrument.

These general principles being understood, we proceed to describe the details of the several types of instruments.

The range of each instrument is from 1 to 50 times the smallest for which its sensibility suffices. The ranges of the different types of instrument regularly made are:

The centi-ampère balance from 1 to 50 centi-ampères.
The deci-ampère balance from 1 to 50 deci-ampères.
The ampère balance from ½ to 25 ampères.
The deka-ampère balance from 2 to 100 ampères.
The hekto-ampère balance from 10 to 500 ampères.
The kilo-ampère balance from 50 to 2,500 ampères.

The general appearance of the centi-ampère, deci-ampère, ampère and deka-ampère balances is somewhat similar to the one shown, but the outer diameter of the fixed coils is slightly greater, and the inner diameter less than those of the movable rings attached to the balance arms.

The position of the movable rings when in equilibrium and equi-distant from the fixed ones above and below it is a position of minimum force, and the sighted position for the sake of stability is above it at one end of the beam and below it at the other, in each case being nearer to the repelling than to the attracting ring by such an amount as to give about $\frac{5}{16}$ per cent. more than the minimum force.

In order to adapt these balances for alternating currents a special mode of arranging the conducting circuit has to be adopted. In the balances intended for alternate currents (which may be used also for direct currents) of from 5 ampères to 250 ampères, the main current through each circle, whether consisting of one turn or more than one turn, is carried by a wire rope, of which each component strand is insulated by silk covering, or otherwise, from its neighbor, in order to prevent the inductive action from altering the distribution of the currents across the transverse section of the conductor, while to avoid induced currents in these parts the coil frames and base board are constructed of slate.

The Electro-Engraving Machine.

The art of engraving is perhaps one of the oldest in existence, and still we find improvements being made in it, a most recent one, especially, being of such a nature that it will no doubt have considerable influence on the art in general. Attempts have often been made to substitute a machine for the engraver's hand, but though success has been in a measure attained, recent progress, which has called to its aid electricity, has brought the engraving machine far in advance of its former position. Without entering into the construction of the older machines, we will at once proceed to describe the machine now being introduced by Mr. H. W. Thornton, of this city, which presents some decidedly novel features.

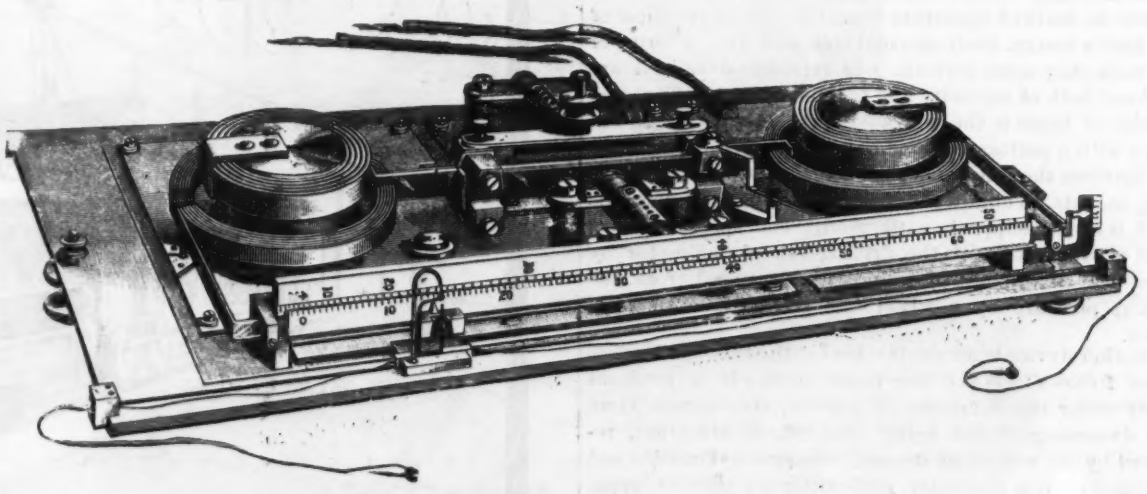
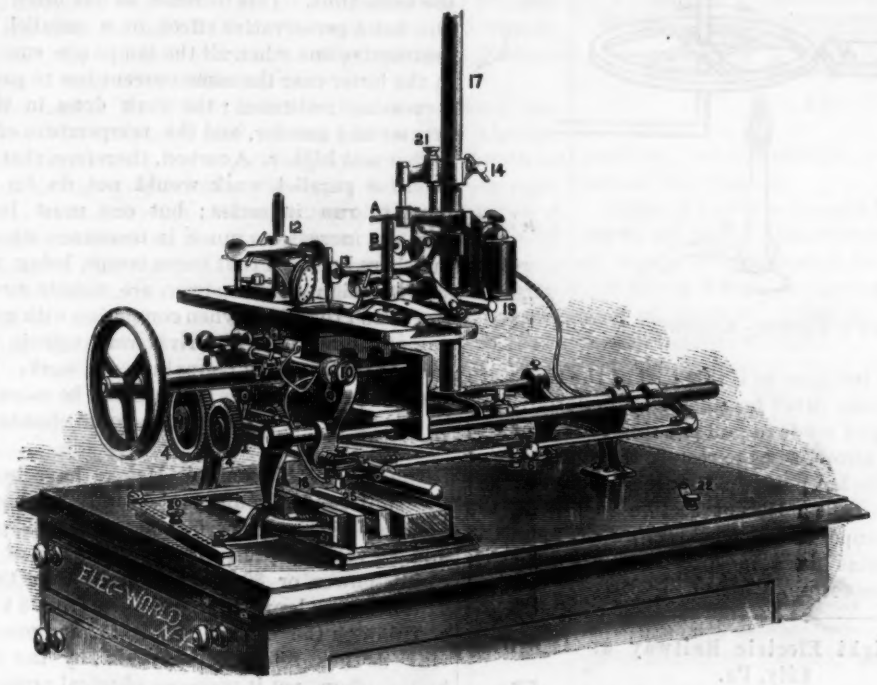


FIG. 1.—SIR WM. THOMSON'S NEW ELECTRIC BALANCE.

The idea embodied in the machine, shown in perspective, in the accompanying illustration, is to allow an engraving tool to work upon the substance to be engraved in exact accordance with a model or pattern, which is included in an electric circuit. The machine consists of a graving tool 18, which is supported at one end of a pivoted bent

lever, the other end of which carries an armature which is placed opposite the poles of a horseshoe electro-magnet. The pattern which it is desired to reproduce, and which we will assume to be in the form of types in this case, is held in a clamp, and placed below the rider 5, which supports a small rod of glass, through which passes a platinum wire, ending flush with its lower surface. The electric circuit coming from a battery contained within the case, is led to the types, and is completed through the platinum within the glass rod, passing thence to the electro-magnet and back to the battery. It will now be readily seen that whenever the rider



AN ELECTRIC ENGRAVING MACHINE.

supporting the platinum passes over the surface of the types, the electric circuit is closed at that point; but it is interrupted when passing over the blank part of the type. The electro-magnet, energized in accordance with the contacts so made, attracts the armature and lifts the graving tool from the surface to be engraved, so that the motion of the small platinum wire passing over the types is reproduced exactly in the vertical motion of the graving tool. Now, if at the same time the substance to be engraved upon is moved back and forth while the graving tool is moved upward and downward by the action of the current, it is evident that the engraving made will be an exact reproduction of the type surfaces. The additional details of the apparatus are quite simple. By moving a large handwheel to the right the platinum contact wire is passed over the types and makes its contacts, which are followed by the graving tool, and at the same time the substance to be engraved upon is moved laterally. At the end of the stroke, the hand-wheel is turned to the left; this automatically closes the electrical circuit, and lifts the graving tool clear from the material to be engraved upon. But during the return stroke of the wheel, the platen, upon which the material to be engraved upon is fastened, is moved backward a certain distance, so that the graving tool engraves a new line at the next stroke. When the circuit is broken, a spring *B* brings the tool down upon the work.

It will be noticed that by lifting the graving tool from the material when the circuit is closed by the type, the etters will appear in alto relief, those parts of the material to be engraved not being touched; but it may also be required to engrave in bas relief. This is provided for in the apparatus in a very ingenious manner. It will be noticed that the pivoted lever which carries the graving tool has an additional arm carrying the armature 19 at its end. The electro-magnets are pivoted at the yoke, and when it is desired to engrave in bas relief, they are turned down to a vertical position, as shown, to bring their poles opposite the armature 19. Now it will be evident from the construction, that when the circuit is closed by the type the armature 19 will be attracted upward, and bring the graving tool down upon the material, while, when the circuit is open, the graving tool will be lifted clear of the material. In this way sunken work can be accomplished very easily.

The apparatus is so arranged that the engraving can be increased or reduced in size from the original to any desired extent. This is accomplished by means of the pantagraph arrangement, 20 and 6, by which both the height and the breadth of the engraving can be regulated, independent of each other. Two or three cells is all that is required to work the instrument, and the work which it accomplishes is of the most varied character, as we have had occasion to observe. By using a diamond tool, glass, stone and a whole variety of materials can be engraved, and all kinds of surfaces, straight and curved, can be worked with the greatest ease.

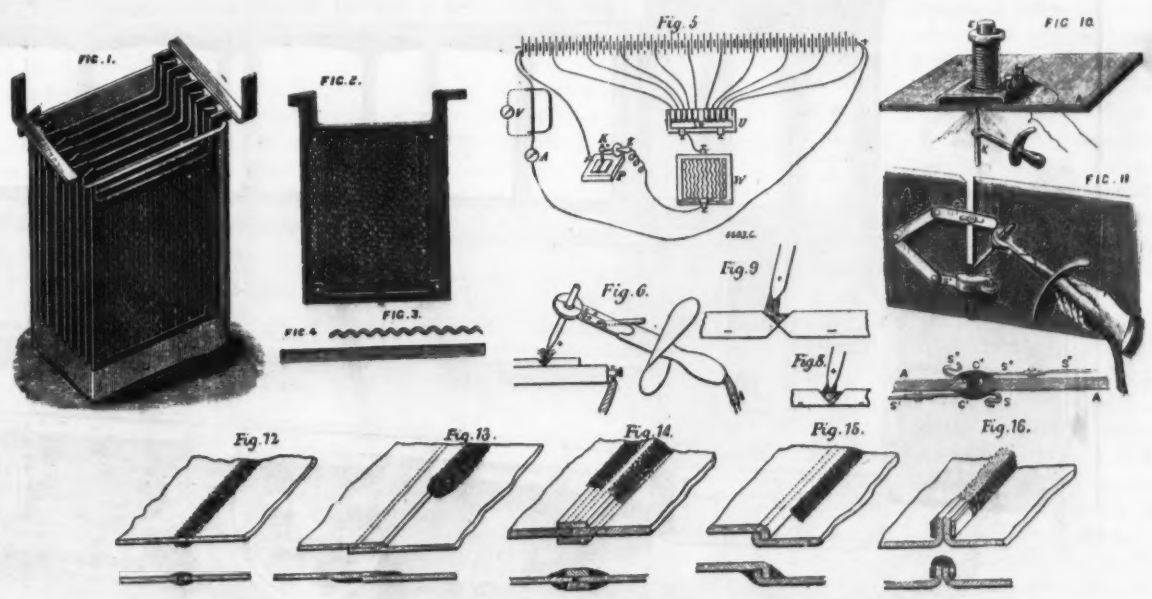
Among the specimens of work accomplished by the apparatus, we have seen an engraving of the Lord's Prayer, done upon an agate cuff button of the size of a silver dime.

Electric Welding by Means of the Arc.

We have already described and illustrated the process of M. de Benardos* in which the electric arc is employed as the medium of fusing two pieces of metal at their joints, and we now illustrate the latest advances made with the process. M. de Benardos works directly with the electric arc produced between a carbon pencil as one terminal, and the metal to be treated as the other terminal. This has been suggested and tried before. But the carbon was made the negative pole, as it was feared that otherwise the consumption would be embarrassingly rapid. Hence the metal became the positive pole; that is to say, it became exposed to energetic oxidation; and a great deal of the trouble experienced by other experimenters arose from this circumstance. In the Benardos process, the carbon forms the positive terminal; it is, of course, quickly consumed, but can easily be replaced. On the other hand, there is a favorable reducing action going on in the fused metal. The great importance of this modification can easily be tested by changing the poles, when the work soon becomes enveloped in a dense cloud of oxidized products. The intense heat of the arc melts even the most refractory metals almost instantaneously; but the action is purely local, like that of the blowpipe, and only those parts upon which the arc plays directly are attacked, the adjoining portions undergoing little change; and the fused mass solidifies and cools very quickly. In the Benardos process the material requires little or no preparation. Even a pretty thick layer of oxide will be reduced and drop off, while smaller quantities of oxides unite to form a slag with the sandy clay frequently added as a flux. This slag prevents the oxidation of the metals while cooling. No other fluxes are required. The operations can also be carried on under water, although the gases and steam generated cause trouble. Nevertheless an apparatus has been constructed to facilitate such work by forcing the water away from the parts to be treated by means of compressed air. One of the chief advantages claimed for the new system appears to be that the arc is brought to the work, and not the work taken to the arc, which would mean transformers, crucibles or other apparatus. Size is hence a question of secondary importance, and unwieldy pieces may be dealt with, although for soldering work of the ordinary kind a special operating table is employed as more convenient.

In order to obtain the various strengths of current and E. M. F. necessary when operating upon pieces of different size, storage batteries are employed which have been specially constructed for this purpose by M. de Benardos. The complete cell, Fig. 1, weighs 15.9 kilogrammes (35 lbs.) and contains nine lead plates, Fig. 2, all of the same kind, four of them positive and five negative, with 1.25 square metres (1½ square yards) of total surface. Each plate consists of a frame cast of pure lead 16 by 20 centimetres (6 in. by 7¾ in.) surface, and 0.5 centimetre thick (0.2 in.) The interior of the frame is filled with strips of thin lead, alternately straight and corrugated, Figs. 3 and 4, soldered into their places; the latter strips are bent in such a manner as to facilitate upward currents in the liquid. The cells have an interior resistance of 0.002 ohm and give 2.5 volts, when continually charged while at work. Fifty to seventy of these cells are joined in a battery, several batteries, three for instance, are grouped in parallel, and are continually charged by a shunt dynamo. The diagram, Fig. 5, explains the ordinary connections. The shunt dynamo *D* charges the fifty accumulator cells in series; a voltmeter and an ampèremeter are inserted at *V* and *A*. From the positive terminal of every fifth cell a wire leads to a plug switch-board *U*; from *U* the current passes through a variable resistance *W*, and from thence through a flexible cable to the carbon-holder *Z* and the carbon pencil *K*. The operator manipulates his holder *Z*, the metal to be fused, placed upon the table *P*, being joined directly to the negative terminal of the battery. By inserting the plug in the switch-board *U* the operator may obtain currents from five cells, twice five, and so on to ten times five cells. If considerable masses of metal are to be dealt with, currents of considerable strength are needed. These are obtained by grouping the batteries or certain sets of cells in parallel. Supposing the dynamo gives a currents of 175 volts and 120 ampères, that there is a battery of seventy cells coupled in series, and that it is desired to solder two boiler plates of 10 millimetres (⅜ in.) thickness. The carbon-holder is connected with the positive terminals of the fortieth cells of three groups. The carbon pencil is allowed to touch for a fraction of a second, and is taken off again immediately, so that between the plates and the carbon pencil an arc of a few millimetres length is formed. The iron melts like wax; but the action seems too powerful, the molten metal hissing and evaporating distinctly. In such a case one of the three parallel groups is cut out. Should the action then be too sluggish, one or more parallel groups is added. Some times the arc proves too small or extinguishes frequently; in such cases the number of cells in each group has to be increased.

The carbon-holder, Fig., 6, resembles a pair of scissors,



ELECTRIC WELDING BY MEANS OF THE ARC.

and consists of two copper bars having a round hole near the end, in which the pencil is held firmly either by the friction of the parts, or by means of a little wedge, as shown in the illustration.

One of the most important applications of the new process is for welding plates of all thicknesses. For the very finest sheets of 1 millimetre and less, the Electro-Hephaest Company prefer a modification of Prof. Elihu Thomson's process. But all stronger plates up to several centimetres thickness are subjected to the arc.

To effect this with ordinary plates, the edges are feathered, as in Fig. 8 or Fig. 9, and pressed together. The furrows are filled with little pieces of the same material, and the arc is then applied, while fresh pieces are added until the furrow is completely filled with the molten mass. The plates are immediately afterwards finished under the hammer. In making iron welds the small pieces for filling are always of wrought iron. With iron, a flux of clay sand is recommended; with copper, borax or sal-ammoniac. The arrangement, Fig. 9, secures

* See THE ELECTRICAL WORLD, June 11 and July 9, 1887.

great strength, but is, of course, only applicable when the lower surface of the metal can be got at. When the plates are joined on their lower surface, M. de Benardos suggests a powerful electro-magnet placed as indicated in Fig. 10 to prevent the liquid metal (provided the material be para-magnetic) from flowing off. The apparatus shown in Fig. 11 looks more practical; it is intended to be employed when making vertical seams. The pincers S^1 and S^{11} carry two pieces of graphite or coke, C^1 and C^{11}, forming a sort of chamber at the spot where the fusion is to be carried on. As soon as the mass has hardened sufficiently the carbon pieces are pushed further up. Carbon pieces are frequently employed to prevent the flowing off of the fused material. Figs. 12 to 16 exemplify other ways of joining plates in cases where a perfectly straight surface is not insisted upon; for thinner plates the method, Fig. 16, seems to offer particular advantages; for two one-fifth-inch plates a seam of a yard length can be made in seven minutes. When plates are to be joined at an angle the process is, of course, exceedingly simple.

This process also permits of the welding of dissimilar metals so that iron and copper, tin, zinc, steel, cast-iron, etc., can be united.

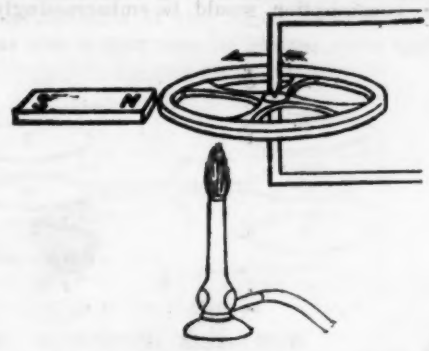
On the Effect of Magnetization on the Thermo-Electrical Properties of Bismuth.*

It has been shown by Sir Wm. Thomson and others that the electrical resistance of an iron wire is increased when magnetized longitudinally, and similar phenomena were shown to occur in steel, nickel, cobalt and bismuth in a paper communicated to the Royal Society in 1882 by the author. On comparing the results, it is found that for the same intensity of magnetization the increase of resistance of bismuth is about two thousand times that exhibited by iron. The author believes the increase of resistance of bismuth to be partly *apparent* only, and thinks that some influence similar to an opposing E. M. F. is operative, but as to its exact nature he can say nothing. Hall's phenomenon suggests itself as a possible explanation, but experiment shows that this is not the true cause. The change of dimensions due to magnetization is found to be too small to produce the effect, and, so far, no satisfactory explanation has been found. On heating a rod of bismuth, when under the influence of magnetizing force, an E. M. F. is set up from unmagnetized to magnetized across the hot junction, having a value of about .0022 microvolt per 1 deg. C. difference of temperature, when the magnetizing force was 226 C. G. S. units. Ettinghausen has found that a difference of temperature is produced between the two sides of a plate of bismuth placed in a magnetic field when an electric current is passed through it; and it has also been shown that if a thermal current be substituted for the electric current a difference of potential is produced.

* Abstract of a paper read by Mr. Herbert Tomlinson before the Physical Society of London, Jan. 28.

Schwedoff's Thermo-Magnetic Motor Experiment.

The recent forms of thermo-magnetic motors have recalled the experiment of Schwedoff, which is illustrated in a recent number of the *Electrician*. As shown in the accompanying illustration, an iron ring is provided with four brass spokes, by which it is pivoted at the centre so as to be free to rotate in its own plane. A steel magnet is brought near one side, and at a distance of about 45° a Bunsen burner is placed. The magnetic permeability of the iron being greatly weakened by the heat from the

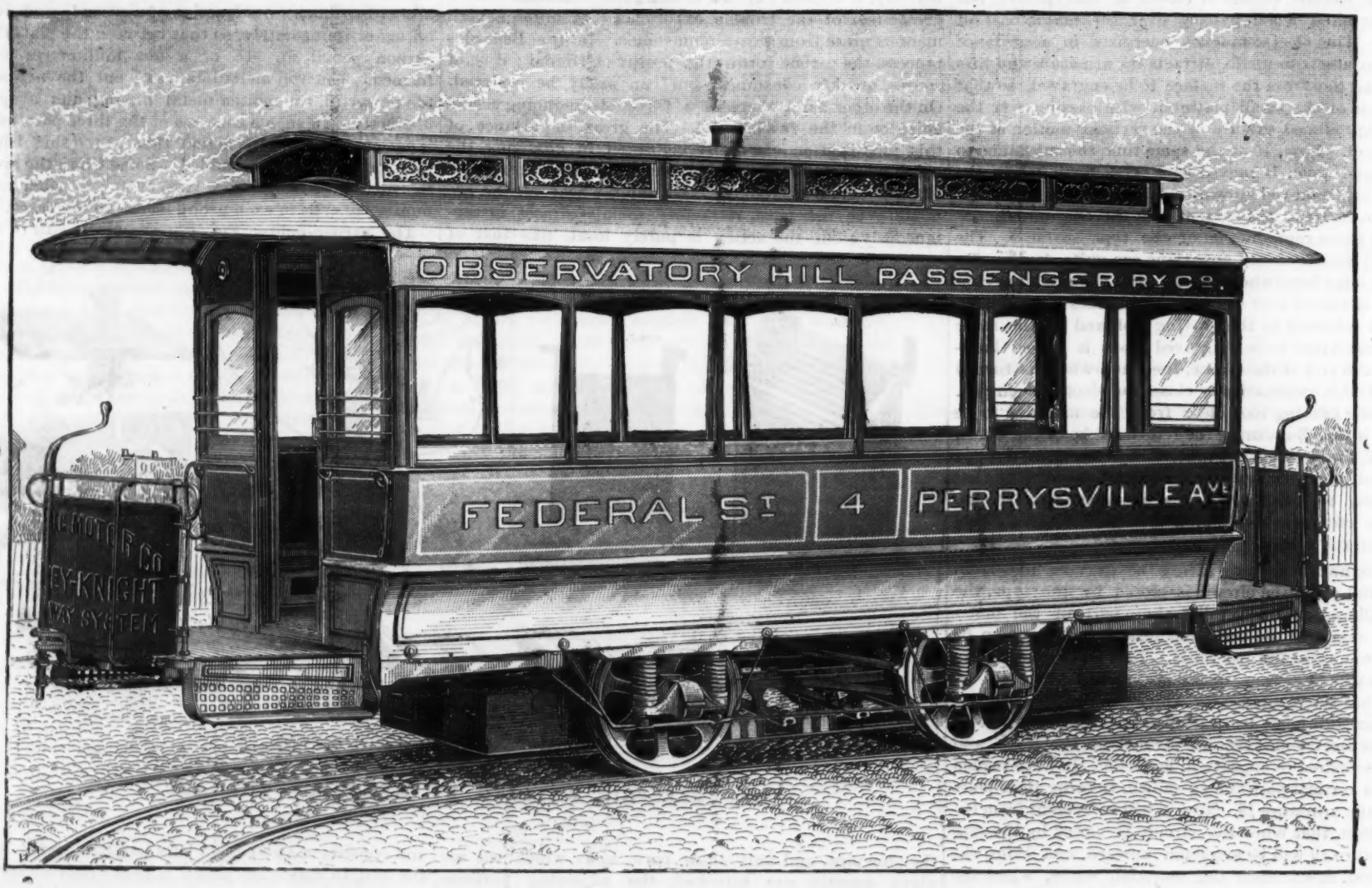


SCHWEDOFF'S THERMO-MAGNETIC MOTOR.

flame, the effect is the same as if this part of the ring were made of brass or some other non-magnetic material; consequently the magnet tends to pull the ring round in the direction of the arrow, so as to restore the symmetry of the field. But as the hot part rapidly cools when removed from the flame, and the adjacent section is heated, the distribution of temperature, and therefore of magnetic permeability, remains fixed in space, and a continuous rotation is therefore set up.

The Bentley-Knight Electric Railway at Allegheny City, Pa.

Our last two issues have contained articles and illustrations of the Bentley-Knight overhead and conduit system as put into operation at Allegheny City. There is no need at the present time, therefore, to go again into the details, but we are glad to present a view of one of the cars actually in use. The cars have each two 15 h. p. Thomson motors, and carry the necessary devices for overhead and conduit contact. They have a speed on the heaviest grades—up to 9.8 per cent.—of 6 miles per hour, with a load of 50 passengers, and on the more level stretches of the road have made 15 to 18 miles an hour, heavily loaded.



DOUBLE MOTOR BENTLEY-KNIGHT CAR, ALLEGHENY CITY, PA.

A Large Check.—A check for $40,000 has been handed over in payment of 4,000 shares of stock in the Nova Scotia Telephone Company at par. The new company is now in possession of the entire plant and property of the old Bell Company in Nova Scotia and New Brunswick.

Series Glow Lamps.*

BY WILLIAM SIEMENS.

The great obstacle which has hitherto prevented this system from coming into more extended use has lain in the manufacture of the lamp itself, for it is no easy task to make a good lamp with a filament large enough to take a current of some ten or more ampères.

One difficulty arises from the necessity for all the lamps to take the same current. An ordinary modern Edison lamp for parallel, running at 3.2 watts per candle-power, increases in resistance about 5 per cent. in an 800 hours run; the old pattern used to increase about 13 per cent. in the same time. This increase, as has often been pointed out, has a preservative effect in a parallel system, but a destructive one when all the lamps are run in series, for in the latter case the same current has to pass through an increasing resistance; the work done in the lamp gets greater and greater, and the temperature of the filament higher and higher. A carbon, therefore, that is sufficiently good for parallel work would not do for lamps which have to run in series; but one must be used which does not increase so much in resistance when running. It may here be noted that series lamps, being almost necessarily of high candle-power, are mostly used for outdoor work, and therefore when competing with gas do not have any advantage over that rival on hygienic grounds, as is the gas with parallel lamps in house work. It is therefore necessary that a series lamp should be more efficient than its congener if it is to stand an equal chance with it in respect to gas.

The firm of Siemens & Halske have been at work on the subject for some years, and are now making 11-ampère series lamps of 50 and 100 candle-power, with 10 and 20 volts respectively; an efficiency of 2.2 watts per candle-power, or 30 per cent. more than their parallel 16 candle-power lamps which require from 3 to 3.2 watts.

Although the carbon used is formed much in the same way as gas retort carbon, viz., by the dissociation of hydrocarbon, yet it possesses physical properties in which it differs not only from retort but also from all other kinds of carbon.

Its specific resistance is 689 microhms, that of a sample of bamboo carbon (unflashed) being 6,014. (Tabulated results of determinations of temperature coefficient of three Siemens and two unflashed bamboo carbons are here given for the temperatures up to 200 degs. C. The Siemens coefficient falls from about .16 per cent. at 16 to .12 per cent. at 200, while the Edison rises from .029 to .036 in one case, and remains at .026 throughout in the other.) The resistances of both carbons reached a minimum at a white heat when the total diminution of resistance was 55 per cent. for the Siemens and 45 for the bamboo. The specific gravities were 2.01 and 1.58 respectively.

All the above properties show the value of this carbon

* Abstract of a paper read before the Elektrotechnische Verein, Berlin, Dec. 27, 1887.

for the purpose required, and after a 500-hours' run the resistance of a lamp was found to have hardly perceptibly increased; and the efficiency had only fallen from 2.25 watts per candle-power to 2.35.

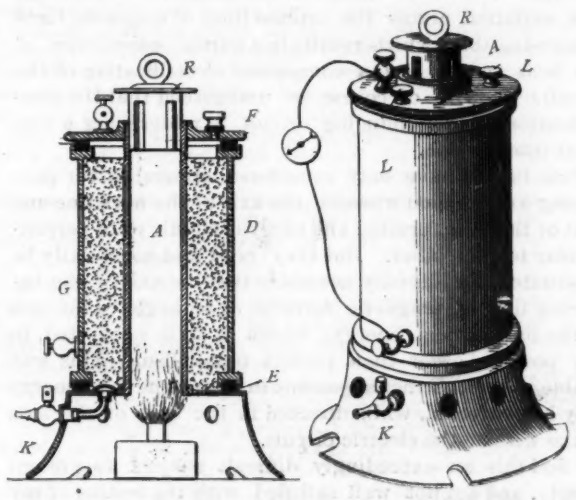
Besides the carbon, other difficulties have to be encountered in large current lamps, in the matter of making good connection to the carbon and of fusing the platinum wires into the glass.

The usual horseshoe filament (or, in this case, rather horseshoe rod) is found to be the best in this as in the ordinary parallel lamp, although, at first sight, a straight rod with leading-in wires opposite to one another would appear preferable. The wires are very long and thick, and naturally very difficult to seal in air-tight. The ends of the filament are considerable enlarged and electroplated (with nickel) into metal cups, which in turn are soldered on to the platinum wires.

The author then describes a rather complicated mechanical device for short-circuiting a lamp when it breaks.

The alternating has a great advantage over the direct machine for series running, owing to the automatic regulation caused by the self-induction of the armature. A Siemens alternating machine, running at 1,700 volts, with 11-ampère glow lamps of 60 and 100 candle-power, showed no appreciable alteration in the remainder when one-third of them were suddenly short-circuited, a greater change than would ever occur in practice.

The author goes at considerable length into the *pros* and *cons* of series running as compared to parallel. The chief argument brought forward in favor of the former system arises from the fact that the distance from the central station at which lamps may be economically run is much increased. Where it is *necessary* that this distance should be very great the series system should undoubtedly be employed. The distance for parallel working is, however, no small one. For example, at Elberfeld



FIGS. 1 AND 2.—RESEARCHES IN THERMO-ELECTRICITY.

the author's firm have installed a central station on the three-wire system for 10,000 16 candle-power lamps, feeding a district some 2½ kilometres (1.3 mile) across.

He is of opinion that the series system has but a limited field, being practically only suitable for streets, tunnels, stations, mills, etc., where lights of 50 and 100 candle-power are wanted, and for which use it has a great advantage over the arc lamps in only requiring attention once in 800 hours instead of once in 8.

The author strongly attacks the Bernstein system of house-to-house lighting by series lamps, on the ground that the lamps cannot be satsfactorily made of sufficiently low candle-power, that they are three times as expensive as parallel ones, that there is considerable danger to life, and lastly, that it is no cheaper, if indeed as cheap, as parallel installations on the three-wire system. The cost for mains he admits is only one-third or one-half of that for parallel running, which he puts at 30s. per 16 candle-power lamp; but against this saving there is the cost of the automatic short-circuiting arrangements, and these he says, will cost as much as to lay down the mains for the whole district on the three-wire system. Besides, the cost for mains is, after all, only a portion of the total expense, and the depreciation on them is not nearly so heavy as on the dynamos and other plant.

Some Researches in Thermo-Electricity.

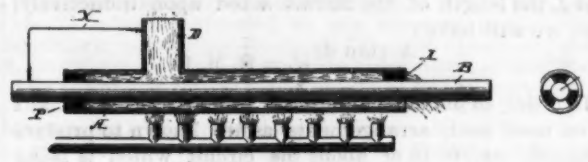
BY E. G. ACHESON, PITTSBURGH.

The interest with which the several references in THE ELECTRICAL WORLD to my thermo and calelectric experiments and patents have been received, has persuaded me to believe that a plain statement of my experiments would be of interest to the readers of this journal. In order that those interested in this line of work may readily understand the construction and results obtained with my apparatus, I think it will be necessary to lead them through the same paths I have trodden. While this does not apply to those favored ones possessing a thorough acquaintance with the physical forces and modes of motion, it does apply to that vast majority whom I hope to interest in this grand problem of the transformation of the physical force, heat, into those peculiar conditions which we recognize as electrical, by what appears to me to be a method of nature's own construction.

A LINE OF MAGNETIC FORCE, A RAY OF HEAT AND A LINE OF ELECTRIC ENERGY.

These are the three elements with which we have to deal, and to me they stand as I have written them, in the order of their simplicity and dependence upon each other.

A line of magnetic force must be a closed circuit, and its existence is apparently independent of the medium in which it exists. It does certainly react upon the



FIGS. 3 AND 4.

medium, but its existence is not dependent on the existence of the medium.

A ray of heat is a straight line from the source of the ray to the point of its interception. It can exist, as a ray of heat, independent of its terminals.

A line of electric energy is a line or axis of energy, with lines of magnetic force closed about it, and surrounding it throughout its length.

It may perhaps be found difficult to imagine, as I have done, a ray of heat to be surrounded throughout its length by closed lines of magnetic force. But this is the first step leading to the theory upon which my experiments have been built. I have furnished the ray of heat with a continuous envelope of lines of magnetic force, the ray of heat forming the axis of the planes bounded by the lines of magnetic force.

An electric circuit is a closed circuit of any such medium, or combination of mediums, as will, upon being subjected at any one point or portion to the combined actions of heat and magnetism, exhibit throughout

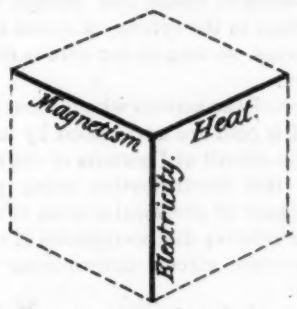


FIG. 5.

its length those properties which we are accustomed to term electrical.

An electrified circuit is an electric circuit containing lines of energy more or less parallel to the axis of the circuit, and closed lines of magnetic force surrounding them.

Assuming that the reader has granted the existence of the lines of magnetic force surrounding the ray of heat, it will be found we now have all of the qualities of the electric line of energy in that of the heat line, *i. e., a line or ray of energy, with closed lines of magnetic force surrounding it.* Is it then too much to suppose that, were it possible to receive a ray of heat into an electric circuit and cause it to pass through the circuit in one direction, that the circuit would be *electrified?* (When I say "pass," I use the word figuratively.) We would have a line of energy parallel to the axis of the circuit, and lines of magnetic force closed about it. I cannot believe otherwise, than

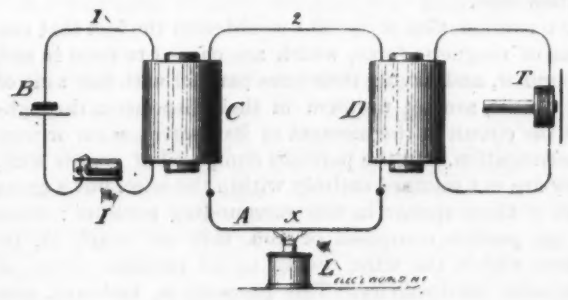


FIG. 6.

that the circuit would be electrified under these circumstances.

We know that many mediums possessed of the qualities necessary for forming an electric circuit are more or less transparent to rays of heat. Let us assume that all of such mediums are possessed of this quality of diathermancy to a certain degree. This being the case, let any two of them be joined together and included in an electric circuit, and rays of heat be intercepted at the point of their junction. Will there not be a greater number of the heat rays passing in the direction of the medium of greatest diathermancy? There undoubtedly will. And, having established the identity of a line of heat and a line of electrical energy, we now have the conditions necessary for producing an electrification of the circuit.

It was this course of reasoning which led me in 1883 to experiment upon the use of a gaseous medium as one of the determining elements of the direction of the radiation.

In Figs. 1 and 2* are shown illustrations of what I have called a thermo-electric generator, in which a gas is used. In this generator two cylinders *A* and *D* are mounted upon the base *K*, the outer cylinder being insulated therefrom by the insulating ring *E*. The upper end of the tube or cylinder *A* was threaded and to it was screwed the cap plate *F*; this plate rested upon the upper insulating ring *E*, and held the cylinder *D* firmly in position. The interior space between the two cylinders was filled with various substances, but more frequently with bioxide of manganese. By means of a small lamp, heat could be imparted to the central tube *A*, and through it to the bioxide of manganese, thus causing a liberation of oxygen. This oxygen, I conceived, enveloped the various particles of the manganese bioxide from which it was liberated. The conditions being thus, we would have, by connecting the cylinder *A* to cylinder *D* by means of a wire, an electric circuit, through which the heat energy applied to the cylinder *A* would be directed by the relative diathermancy of the mediums.

I obtained an E. M. F. of 2¼ volts from this generator, but its possible economy, I have, as yet, been unable to determine. The rings *E E* were of rubber in the apparatus I used and I consequently never applied high temperatures. The internal resistance was great at these low temperatures, and the resulting current in ampères small. This was done in 1883 and before, at which time I was not familiar with the rapid decrease in the resistance of a gas with increase of temperature; hence I did not know the advantages I would have gained by using high temperatures.

The small amount of current obtained with the gaseous generator, together with the discouraging opinion of Count du Moncel, who ascribed the electricity evolved to pyroelectricity, as developed in a crystal of bioxide of

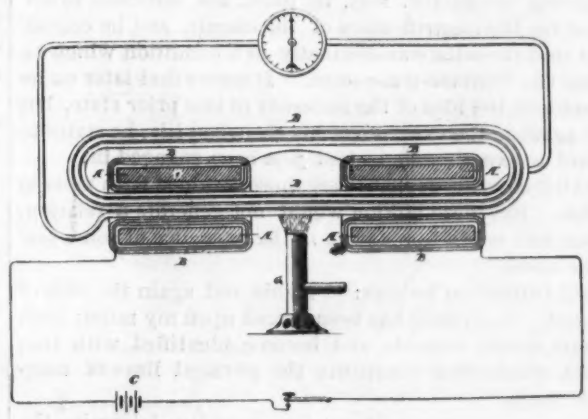


FIG. 7.

manganese, caused me to turn my attention to the use of a liquid medium in place of the gaseous one.

My first experiments were discouraging, owing to the rapid drop in the E. M. F. I found, however, that so long as a movement of the mediums at their contact surfaces occurred, the E. M. F. would fall. This resulted in the construction of an apparatus like that shown in Figs. 3 and 4, in which the rod *B*, the wire *X*, the tubes *D* and *A*, and the liquid which is caused to enter and flow throug *D* into *A* and discharge at *I*, from the electric circuit, and the heat being applied to *A* is caused by the relative diather mancies of the liquid and the tubes and wire to electrify the circuit.

Unavoidable circumstances compelled me to lay aside my work in this line in the latter part of 1883, and I did not take it up again experimentally until the early part of the summer of 1886, when it occurred to me that it might be possible to electrify a circuit by setting up a relative motion between the circuit and a ray of heat or light.

With this object in view, I constructed a tube of tin twelve feet in length and two inches in diameter, one end being made to open out like a funnel. A shutter was arranged in the tube at the neck of the funnel, and a gas flame was mounted in front of the funnel, with a reflector back of it. With this arrangement the radiant heat of the gas flame could be made to pass through the tube, either continuously or in momentary flashes. On the outside of this tube I mounted wire in all possible ways and directions, and tested each arrangement for indications of electrification at the moment of the passage of the heat rays. My galvanometer was a very heavy, sluggish instrument, and, thinking my failure to detect an electric development was due to it, I substituted a telephone receiver, but all to no avail; my results were all negative.

It was after I had exhausted this subject to the best of my ability, and in the month of July, 1886, that I thought I might electrify a circuit and at the same time prove the existence of the lines of magnetic force around the heat ray by causing the heat to radiate across or against lines of magnetic force.

The medium occupying the field of magnetic force and through which the heat would radiate, must, of course, be one of those mediums popularly called an electric conductor. Accordingly, electro-magnets were arranged in whose fields various conductors could be placed and

*At the request of Mr. Acheson we reproduced the illustrations which have already appeared in these columns.—EDS. E. W.

through the conductors heat caused to radiate. I was rewarded by obtaining an electrification of my circuits, and a series of experiments, roughly made (as I was restricted in the amount and quality of my apparatus), demonstrated the fact that the three lines of motion were at right angles to each other. Or, as I was the habit of thinking of and sketching them, they were like the three convergent edges of a cube, as shown in Fig. 5.

Circumstances once more compelled me to lay aside my work on this subject; but it was the recreation ground of my mind and my constant study. It was during this interval that I chanced to see in the London *Electrician*, under date of Feb. 18, 1887, an account of the experiments of Messrs. Hinghausen and Nerust.* My facilities had not permitted of my obtaining a measurement of the E. M. F. produced by the cutting of the lines of magnetic force by the heat lines, but from my experiments I had recognized the difficulty of obtaining an E. M. F. of a practical value. But now the work of the Vienna experimenters had confirmed my work, and strengthened me in the opinions I had deduced, viz., that to obtain an E. M. F. of a practical value, it would be necessary to transpose the heat and magnetic lines, and *cause the lines of magnetic force to move upon or cut the heat lines.*

My first experiments in this direction were a series of tests with apparatus constructed of iron or lead pipe, coiled about a core of iron. Around the same core of iron carrying the pipe I coiled a circuit of wire, the pipe and wire occupying the relation of primary and secondary circuits. A battery was used to electrify the wire circuit. Through the pipe was passed dry steam, hot oil or water.

My results were variable. The awkwardness of the apparatus and want of proper facilities to handle them caused me to turn my attention to the use of wire only.

Faraday early in his experiments was struck with the fact that the simple cutting of lines of magnetic force, by a moving conductor, was, in itself, not sufficient to account for the electrification of the circuit, and he considered that the wire was originally in a condition which he called the "electro-tonic state." It seems that later on he abandoned the idea of the necessity of this prior state, but still again in the eventide of his electrical life, he states in regard to experiments he had just been engaged in:

"All the results described are those obtained with *moving metals.* But mere motion would not generate a relation, which had not a foundation in the existence of some previous state."

Still further on he says: "Again and again the idea of an *electro-tonic* state has been forced upon my mind; such a state would coincide and become identified with that which would then constitute the physical lines of magnetic force."

Have we the means at our command, to determine the existence, or non-existence, of this anterior state? The absolute determination of this state is probably beyond the province of man; but let us, by a course of reasoning, try to deduce the existence of such a state.

At all temperatures above absolute zero, heat will be resident in, and tend to radiate from, a wire of metal; but having accepted the theory of the closed lines of magnetic force surrounding a heat ray, we will have both heat and magnetic lines in the wire, and, furthermore, I am right, I think, in stating that the heat rays radiated from the inner portions of the wire will assume the direction of the radii with the centre of the mass as an axis.

This being accepted, we have lines of energy, surrounded by closed lines of magnetic force, in directions perpendicular to the axis of the electric circuit, and were it possible to see with our eyes a line of magnetic force, the surface of the wire would be cut by magnetic circles, the axis of the plane of each circle being perpendicular to the electric axis of the circuit.

Assuming these conditions to exist, would not the formation of a sufficiently powerful line of magnetic force, with the axis of its plane parallel and preferably concident with the axis of the electric circuit, cause the lines of magnetic force surrounding the lines of heat energy to set themselves in polarity opposed to the inducing line of force, and with their planes tending more or less towards parallelism with the plane of the inducing line of magnetic force?

Such seems to me to be not only the possible, but the probable actions of the forces under these conditions.

What have we as the result of this deflection of the direction of radiation? We have a line or axis of energy, approaching more or less to parallelism with the axis of the electric circuit, and closed lines of magnetic force surrounding the line or axis; but as we have at the beginning of this subject defined an electrified circuit to be one under these same conditions, we are led to believe that our present wire will, if closed into a circuit, be found to be electrified, and if it is so, then have we established the existence of that prior state, the *electro-tonic state* of Faraday.

I would suggest the term *caloric state* for this anterior condition, and in this connection I would say that with all due regard to the erroneous ideas which were of old associated with the word calor, I cannot but think it is a more appropriate name for this energy. The word heat has entered so completely into our every-day life, that it ceases to have the proper meaning.

* THE ELECTRICAL WORLD, April 9, 1887.

Without attempting to enter into the mathematical problems here presented, and which, I know, can be treated by others in a much superior manner than I could hope to accomplish, I will venture to suggest a formula for computing the E. M. F. of a closed circuit which is acted upon inductively, for we will find it necessary to refer to this E. M. F. further on.

Let T represent the time occupied in making the deflection of the axis of energy; X, the potential of the axis of energy, due to its temperature; d, the angle of deflection, and L the length of the circuit acted upon inductively; then we will have:

$$\frac{X\ (\tan\ d)}{T}\ L = \text{E. M. F.}$$

In order to obtain the highest value for the E. M. F. I have used such arrangements as are known to produce *magnetic whirls* in or about the circuit which is being inductively acted upon.

Fig. 6 shows such an arrangement of apparatus and circuits. A is a fine iron wire in circuit with low resistance coils C and D; B is a gravity cell, in circuit with a low resistance coil C; I is an interrupter, which should interrupt the circuit about 200 times per second, to obtain good results; T is a telephone receiver, and L a lamp or gas jet.

The coil in D to which the telephone T is connected should be of a resistance appropriate to that of the telephone.

With these connections and the wire A cold, we obtain, upon interruptng I, the ordinary induced electrification of the circuits 2 and 3, and the consequent sound in the telephone; but if, while the operation is being continued, heat be applied to A at a point x and its temperature increased to a full red heat, we will notice when a certain temperature is attained, a sudden increase in the volume of sound in the telephone. It is not a gradual increase but a sudden one. The temperature being lowered below this critical point, the drop in the volume of sound to its original value is equally sudden, The experiment can be repeated any number of times and always with like results. This increase in the volume of sound is not momentary, but continuous, so long as the wire is retained at this high temperature.

The explanation of the actions which occur in this device when the wire A is cold are understood by me as follows: The closing of the circuit at I permits of the electrification of the circuit 1, this electrification being produced and sustained by the heat of chemical actions at the surface of the zinc, and the relative diathermancies of the conjoined portions of the electric circuit determining the direction of electrification.

At the moment of the electrification of the circuit 1, the lines of magnetic force surrounding it, together with the intensifying effect of the core of the coil c, act by induction upon the lines of force in the wire of circuit 2, causing them to be deflected and throwing their axes of energy to a position more or less parallel to the axis of, and resulting in, the electrification of the circuit 2, which in a similar manner would electrify circuit 3. But immediately the electrification of circuit 1 is established, the lines of magnetic force surrounding the lines of energy in the circuit 2 cease to be further deflected, but remain stationary, and as we found the E. M. F. in the circuit to be

$$\frac{X\ (\tan\ d)}{T}\ L,$$

there will be no E. M. F. in the circuit; hence no electrification of the circuit can exist, and as a natural result circuit 3 is no longer electrified.

On the interrupting of the circuit at I, the same phenomena will occur, with the exception that the circuit will be polarized in the opposite direction to that of the former case.

An examination of circuit 2 would elicit the fact that the lines of magnetic force, which are caused to form in and around it, and having their axes parallel with the axis of the circuit, are not uniform in their disposition throughout the circuit at the moment of its electrification or non-electrification. In the portions composed of copper wire, they are not retained entirely within the wire, but a great part of them appear in the surrounding medium; while in the portion composed of iron, they are nearly all retained within the wire, owing to its peculiar virtue of magnetic conductivity. This property is, however, possessed by iron at certain temperatures only, being lost when heated to a high degree.

In order that we may increase what I have ventured to call the *caloric state* of the circuit, it will be necessary to introduce more lines of heat energy or to strengthen those already existing, and in order to utilize these added lines of energy, we must act upon them at the points of their entry and exit with inducing lines of magnetic force of different values. This is accomplished in the apparatus illustrated in Fig. 6 by heating the iron wire A at a point x, to a degree sufficient to destroy its magnetic conductivity, thus weakening or reducing the number of the lines of magnetic force in the wire; and through this weakened field introducing the heat energy, which will deflect to the cooler portions to the right and left of the heated point and again turn outwards. But on their outward radiation the lines of heat energy will meet with stronger lines of magnetic force than those through which they entered.

On the formation or disappearance of the inducing lines of magnetic force, the lines of heat energy, both on entering and leaving the circuit, will be deflected to a position tending towards parallelism with the electric axis; but the direction of deflection of those entering will be opposed to those passing outwards. The difference in the number or intensity of the inducing lines of magnetic force acting upon the heat energy at its points of entry and exit will produce a balance of deflection in favor of the more intense field; and, consequently, a predominating amount of energy will be directed in one direction, which will result in the electrification of the circuit, over and above that resulting from the original caloric state of the circuit.

It will, of course, be evident to all, that the lines of magnetic force that are utilized, in the case described, to convert the heat energy, are those associated with and surrounding the axes of energy resident in the circuit, and not the lines of magnetic force which, acting inductively upon the circuit, caused its electrification. The conversion of the heat energy in this case, increases or adds to the effect known as the *extra current*, and which I would prefer to call the self-electrification.

It will be evident that many arrangements of apparatus may be made by which the heat energy may be acted upon directly by the original, inducing lines of magnetic force. One such construction is copied from my patent and shown in Fig. 7. It is not of a design I think most desirable, but will serve to illustrate the subject.

A A are cores of iron wound with the coils B B, having the battery C in circuit. Through the centres of the coils B B are passed the convolutions of the coil D. G is a source of heat by means of which heat can be applied to the coil D at a point between the coils B B. The heat energy entering the circuit D at a point outside of the magnetic fields or whirls produced by the coils B B, passes along the circuit, and attempts to radiate at the cooler portions within the influence of the magnetic whirls, but this radiation across the intense lines of magnetic force composing these whirls results in a partial conversion, of the heat energy, and a consequent electrification of the circuit. It will, of course, be understood that the electrification of the inducing circuit, is undergoing a constant interruption.

Thus far we have only considered apparatus for producing a conversion wherein the axis of the heat line and that of the wire forming the electric circuit were perpendicular to each other. But they need not necessarily be so situated, for it is only necessary that the axis of the inducing line of magnetic force be at an angle to the axis of the line of heat energy, which is to be converted, in any position other than perfect parallelism. This will enable us to construct apparatus in which the heat energy may be converted, while directed in the line of the axis of the wire of the electric circuit.

I find this an exceedingly difficult subject to present clearly, and am not well satisfied with the results of my efforts in its presentation, but can only hope that I may succeed in interesting others in this field of research.

Nickel Plating Solution.

According to the *Bulletin Internationale de l'Electricité*, the following solution is employed for nickel plating by several firms in Hainault. It is said to give a thick coating of nickel firmly and rapidly deposited. The composition of the bath is as follows:

Sulphate of nickel	1 lb.
Neutral tartrate of ammonia	11.6 oz.
Tannic acid with ether	.08 oz.
Water	16 pints.

The neutral tartrate of ammonia is obtained by saturating tartaric acid solution with ammonia. The nickel sulphate to be added must be carefully neutralized. This having been done, the whole is dissolved in rather more than three pints of water, and boiled for about a quarter of an hour. Sufficient water is then added to make about sixteen pints of solution, and the whole is finally filtered. The deposit obtained is said to be white, soft and homogeneous. It has no roughness of surface and will not scale off, provided the plates have been thoroughly cleaned. By this method good nickel deposits can be obtained on either the rough or prepared casting, and at a net cost which, we are told, barely exceeds that of copper plating.

Effects of Heating Platinum Wire.

To the Editor of The Electrical World:

SIR: Will you please inform me (1) whether iridium wire will crack when brought to incandescence in the atmosphere or in the presence of hydrogen gas, as observed by Draper, Graham, Edison and others in the case of platinum wires? Also (2), whether platinum wire tempered by the Edison process retains its qualities when again exposed to the atmosphere? J. H. S.

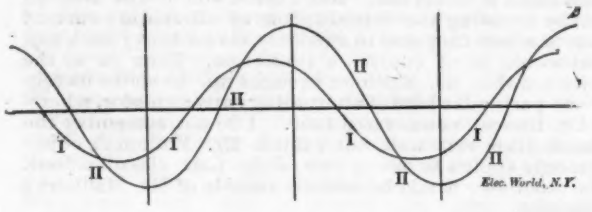
ANSWER.—(1) Iridium wire cannot be made, as iridium is a brittle metal. A platinum-iridium wire (having 20 per cent. iridium) is, however, made, which is harder than the pure platinum wire. All these metals crack when heated, but if brought up by Mr. Edison's process they do not crack, and are elastic at a white incandescence in a vacuum. (2) We are not informed of the effects upon the wire so treated when if exposed to the atmosphere.—EDS E. W.

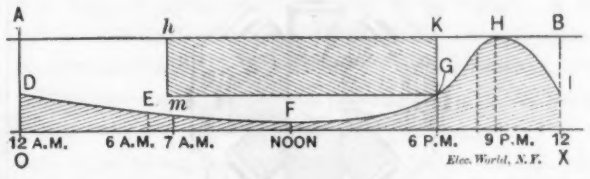
Alternating Current Electric Motors.*

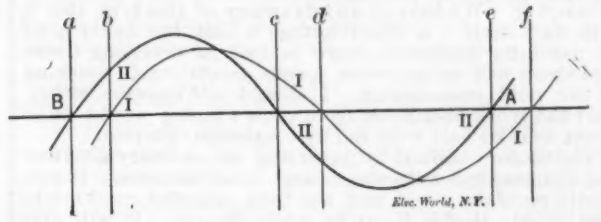
BY DR. LOUIS DUNCAN.

The alternating system of electrical distribution, possessing as it does many advantages for distributing electrical energy over extended areas, possesses certain disadvantages, among others that of not, at present, allowing the use of electric motors for the distribution of power. Let us, before taking up the special subject for consideration to-night, briefly review the general subject of alternating current distribution.

In this system are employed currents of high and constant potential, varying from positive to negative many times a second. If we represent current and potential by curves whose heights above a horizontal line represent ampères or volts, the horizontal distance representing intervals of time, we will have something like the following, Fig. 1. *I* representing current, *II* representing electromotive force; the maximum value of the current lagging behind the maximum of E. M. F. in a way that you were shown recently by Mr. Stanley.







FIGS. 1, 2 AND 3.—ALTERNATING CURRENT ELECTRIC MOTORS.

The high potential used in the dynamo or primary circuit would not be suitable for incandescent lighting and would be dangerous; it is, therefore, reduced to a low potential at points of consumption by "transformers;" that is, induction coils working backward. Now, the whole beauty of the system lies in this, that by using high potentials in the primary circuits we can transmit a great deal of energy with comparatively little current and, therefore, with little loss in the lines. This enables us to use small conductors and to avoid the large investment in copper necessary in distributing energy by the direct system.

In any central station supplying electric lights the full capacity of the plant is utilized but a short time during the day, and taking the whole twenty-four hours we will find that we have sold an amount of energy equal to a half or a third—perhaps even less—of the amount we could supply supposing there was a demand for it all. Let us represent by a curve, Fig. 2, the amount of current used during the day in a constant potential system; the potential being constant, the energy will vary with the current, it being equal to *C E*.

The amount of energy we could have sold is represented by the total area *A O X B;* the amount we have sold is the area *D E F G H I X O*. If we had been able we would have three times the receipts, with expenses perhaps half again as much as in the first case.

A great problem before electricians is to fill the vacant spaces, *A D E F G H A* and *H I B*. There are two ways to partially accomplish this. Suppose, in the first place, we put electric motors on the circuits and sell power during the day. What effect will that have on our diagram? If the motors are at work from 7 A. M. to 6 P. M. we can sell so much power as will at no time make the sum of the power and the energy used for lights greater than the maximum capacity of our station. The area representing the power we can thus sell is shown by *G K h m* on the diagram. The total solid part of the diagram is all that an alternating system can supply; the direct system could fill the entire area by using storage batteries.

Our knowledge on the subject of alternating currents is largely due to the work of M. Joubert and Dr. John Hopkinson. The latter showed first that alternating dynamos could be coupled in parallel, and afterwards that one dynamo could be used to drive another as a motor. He brought forward experiments tried by Prof. Adams and himself, in which one dynamo had driven another, the latter doing mechanical work. Mr. Siemens at the same time, in 1885, described experiments where he had driven both alternating dynamos and ordinary series motors by alternating currents. Dr. Hopkinson's mathematical work assumes that the curve representing E.M.F. is a simple sine curve; that is, that $E = E_0 \sin 2\pi \frac{t}{T}$; it is important to notice, however, that his principal conclusions do not depend upon this assumption, but would be true if the E. M. F. were any periodic curve. Since that time nothing of importance has appeared on the subject excepting two short papers, one by Mr. Kapp on "The Maximum Work Obtainable from a Given Source of E. M. F.;" the other by Mr. Blakesly on "Conditions of Maximum Efficiency in the Case of Transmission of Power by Alternating Electric Currents."

In all of the mathematical work done on this subject it has been assumed that the various E. M. F.'s may be represented by a sine curve, and that only simple electromagnetic actions enter into the problem. I do not believe that these assumptions are true. Since Joubert's experiments, made in 1881, it has been known that the curve of E. M. F. of a Siemens alternating dynamo, where the external circuit had no statical capacity, was very nearly a sine curve. With some of the machines used to-day, and under the much more complicated conditions of distribution, this is probably not even approximately true. Neither is it true that the statical actions of the different forms of wire upon each other in the transformers can be neglected. Messrs. Hutchinson, Wilkes and myself have lately experimented on this subject, and we have obtained the curves for the currents in the secondary and primary circuits under many conditions. These observed results do not agree with the results of calculation in the few cases that we have worked out. Until we have fully satisfied ourselves in this matter I will avoid any but the simplest mathematical work.

Alternating current motors are not in successful use; let us try to find out the difficulties they present and attempt to suggest plans for overcoming them.

The energy being transformed at any moment in any dynamo-electric apparatus—in which I include dynamos, motors, transformers, etc.—is equal to the product of the current by the electromotive force produced by the apparatus. In a dynamo, for example, the amount of mechanical energy being transformed into electrical is *E C*, where *E* is the electromotive force produced by the dynamo; in a motor the electrical work transformed into mechanical is *e C*, where *e* again is the E. M. F. produced by the apparatus, the counter E. M. F. of the motor. This is true for alternating as well as for direct current apparatus. Generally we have:

Work = *E C*. This is + for a dynamo — for a motor.

In alternating circuits *E* and *C* are constantly changing. If we represent them by curves, as before, we must multiply each value of *C* by the corresponding value of *E*, and if we add all these together from *A* to *B*, Fig. 3, we will have the work done by the current in one period. Now if we consider values above the horizontal + and below it —, we have from *e* to *d* a + value of the product, from *c* to *d* a — value, from *c* to *b* a + value, from *b* to *a* —.

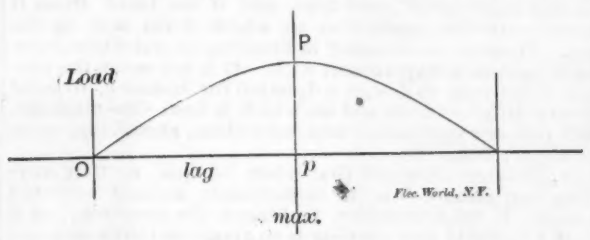


FIG. 7.

The total work done then is [*e* to *d*] + [*c* to *b*] —[*d* to *c*] — [*b* to *a*].

Now we see that if we shift *II* forward or pull *I* back, we have this work less even, though the curves themselves remain the same size. Now this is one of the exceptions I take to the alternating system. In a direct system as the work decreases the current decreases, and the heating of the mains becomes proportionally less, since it varies as C^2; for example, if the maximum loss in the mains of a direct current plant were 10 per cent. of the average, I imagine that the average loss is not over 3 per cent. In an alternating current plant, a decrease in the consumption of energy decreases the current very little; it simply shifts its position with respect to the E. M. F., and the heating, approximately equal to $\frac{C_0^2}{2} R$, remains nearly constant. A maximum loss of 2.5 per cent. would probably mean an average loss of at least 2 per cent. This same remark applies to transformers and motors, and the average efficiency of the former will be considerably less than the maximum efficiency.

A distinction between continuous and alternating current apparatus is this: In continuous current dynamos and motors the cores making up the windings of the armatures make different angles with the lines of force in the field, and the result, when the armature rotates, is a constant E. M. F. fluctuating but little; in alternating dynamos and motors the alternate coils are symmetrical with respect to the alternate poles, the remaining coils being symmetrical with respect to similar poles of opposite signs. The result is a varying E. M. F., changing as has been shown. In dynamos the effect of this is that the power applied either varies from zero to a maximum each period, or the armature changes its speed at different points and oscillates with a period equal to that of the E. M. F.

FIG. 8.

Let us now consider what takes place in the case of two motors, one continuous, the other alternating, one between mains where a constant continuous E. M. F. is maintained, the other where there is a constant alternating E. M. F. In the first case representing current and E. M. F. by curves, we have been doing, we will have two straight lines, Fig. 4, one above, the other below our horizontal axis, the former representing current, the latter the counter E. M F. of the motor. Reckoning time along the axis we have for the energy transformed in the interval from *a* to *b* = — *C E*. As this is — it means that electrical is transformed into mechanical work.

Now, let us consider an alternating current motor built like an alternating dynamo, the field excited by a continuous current. If *A B C*, Fig. 5, are the poles of the field magnets, supposed to be excited by a continuous current, then the curve *I I* will represent the counter or motor E. M. F. If our motor is running slowly there will be two or three reversals of current in the time it takes a coil to go from *A* to *B*, Fig. 6, and the product *C E* will be nearly zero, the positive and negative parts being almost equal. Whether it is + or — is somewhat a matter of chance, and if it is — from *A* to *B* it will very likely be + from *B* to *C*. Thus the armature is pushed first in one direction, then in the opposite, and there is no definite tendency for it to rotate as a motor. This brings us to our first difficulty, a simple alternating current motor will not start itself. Let us suppose, however, that it has been started by some means and has reached such a speed that in the time of a reversal a coil shall have moved over the distance between two similar poles. We will have the state of things in Fig. 5, and the armature will continue to rotate. Now the position of the curve *II* is fixed; we will consider the position of *I* as determined by the position of the armature coils when the current in them is zero; for instance, if the speed increases a little the curve will advance as shown by the dotted line. The total work transformed is the product of the two curves; from 1 to 2 it is —, from 2 to 3 it is +, from 3 to 4 —, from 4 to 5 +. The result is — [1 to 2 + 3 to 4] + [2 to 3 + 4 to 5]; part of the time then the machine is working as a dynamo, part of the time as a motor; the difference of the values represented by the brackets gives the mechanical work that is really available. Now while the available work is the difference of these areas, the difference becoming small as the load is decreased, the heating is the *sum* C^2R for all the values of the current, and is independent of the position of its curve, as has been pointed out above.

Looking at the figure again we see that from 1 to 2 the armature is pushed forward by the current in the line; from 2 to 3 it is pulled back, since it is acting as a dynamo feeding into the line and can only get the energy to produce the current by decreasing its speed and drawing from its energy of motion. The armature oscillates then and it is evident that the amount of its oscillation depends on the kind of work it is doing. If it is driving heavy wheels or machinery having considerable inertia it will only have to slow down slightly when it becomes a dynamo. If it is lifting weights the amount of oscillation will be considerable.

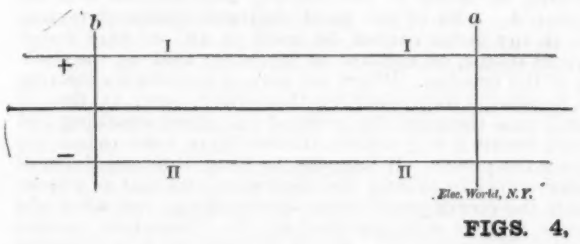
It is evident that there is a certain position of the curve *I* that will make the available work a maximum. If the motor is doing all of its possible work the curve will take up this position; as the load is decreased the speed will increase for an instant until the curve has shifted forward into such a position that the sum of the products — *E C* is equal to the work done. In fact, we can plat a curve representing values of the distance from the point the current curve crosses the axis to the same point when the work is zero corresponding to different loads.

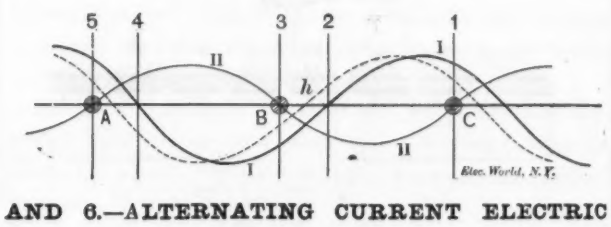
Now the value of this lag, as we will call it, cannot be greater than *O P*, Fig. 7, for although we might extend our curve on the other side, yet a slight increase in our load will cause the armature to fall back, decreasing the available work, and suddenly stop. It is, in fact, in unstable equilibrium.

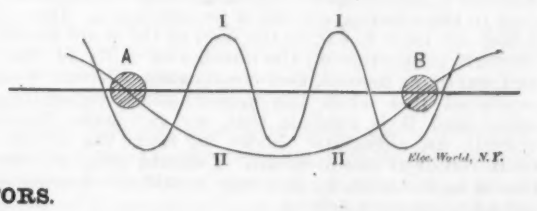
Suppose we have found the value of the lag that will give us a maximum value of the work, and have calculated this value by the ordinary mathematical methods employed, the real work we can obtain is less than this, for the current curve oscillates on both sides of the maximum, supposing we *could* work at the maximum; that is, it is only for a very short time in the best position; so that if we take the sum of the work for a period, it will be less than the calculated maximum. In reality we must work slightly in advance of the maximum, for if we were too near it the curve would fall behind *P*, and will then be in unstable equilibrium and stop. The practical maximum will then vary according to the amount of the oscillation; that is, according to the nature of the work being done.

It seems to me that the possible forms of alternating motors are: (1) ordinary series motor; (2) an alternating dynamo reversed, the field being excited by a continuous current; (3) an alternating dynamo reversed, the field being excited by the alternating current first corrected by a commutator on the shaft; (4) the arrangement suggested by Prof. Thomson, which is described below.

In the first type—a series motor—there is no difficulty in starting; the motor will start of itself. There are these







FIGS. 4, 5 AND 6.—ALTERNATING CURRENT ELECTRIC MOTORS.

* Read before the American Institute of Electrical Engineers, Feb. 14, 1888.

troubles, however: the armature and field must both be thoroughly laminated to prevent eddy currents; the magnetism of such large masses of iron being rapidly reversed will cause losses unless both field and armature are far from saturation; that is, the mass must be great. Again, Mr. Kapp has shown that to obtain the maximum work we must have, approximately, the counter E. M. F. of the motor equal to the E. M. F. of self-induction—a condition almost impossible to realize in practice. The motor must be governed in some way, as it will not govern itself.

The alternating motor with a field fed from the alternating circuit, the current being commutated, will start itself. I do not know if this has been generally recognized. If, in Fig. 8, *A* and *B* are poles and *C* one of the armature coils, the effects of the currents will be as shown by the two sets of signs. The effect of either arrangement is to move the armature in the direction of the arrow. When *C* gets opposite *A* the commutator changes the relative directions of the currents in *C* and *A*, and *C* is repelled by *A* and the armature continues to rotate. The maximum work will, I think, be done when the speed is such that a reversal takes place in a distance *A* to *B*. The mathematical investigation is difficult, and until I am satisfied as to the assumptions usually made I will not attempt it. We have as an advantage of this type that it will start itself; a disadvantage is that the fields must be carefully laminated, there is loss in reversing them, and there will be for some speeds considerable sparking at the field commutator. I should not imagine, either, that the work obtainable from such a moter would be as great as if its field were fed by continuous currents.

The motor obtained by reversing an ordinary alternating dynamo has advantages and disadvantages. It perfectly regulates itself and the field magnets need not be laminated; that is, it can be made cheaply. It will give a greater output from a given source of current than corresponding machines of either of the types already discussed. Its disadvantages are that it must be started independently. We must have a continuous current to excite the field, and if a load having any considerable inertia be suddenly applied the motor will stop. This last objection, by the way, will apply to the type of motor previously discussed, provided, as I have supposed, the maximum work is obtainable when the counter E. M. F. has the same period as the applied E. M. F.

Let us see what means we can employ to start the motor and excite the field. We could start by passing the commutated alternating current through the field as in the second type of motor discussed, changing our connections when the proper speed is attained, so that a continuous current from some external source passes through the field

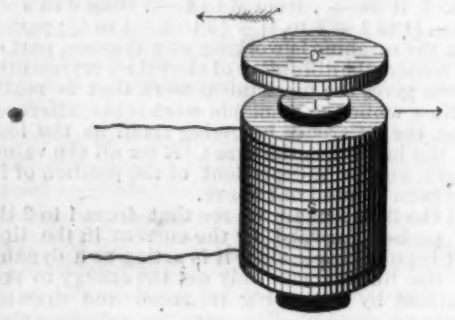


FIG. 9.

and the alternating current is shut off from it. Another way would be to have on the same shaft with our main motor a motor arrangement such as was described by Prof. Elihu Thomson in his valuable paper on alternating current phenomena, read before the Institute. With this arrangement we can do more than start the motor. Prof. Thomson pointed out that when this auxiliary motor reached a certain speed it would produce a continuous current in the external circuit of its armature. This current could be used to excite the field of the main motor. By properly proportioning the number of coils in the main and auxiliary motors, this continuous current would be produced just when the motor had arrived at its proper speed, and it is evident that we can make this current operate an automatic device to make the circuit of the main motor at this moment. I should imagine, however, that a motor made in this way would be expensive and not particularly efficient.

What seems to me the simplest, cheapest, and most efficient means of running alternating current motors is this: build the motor on the same general plan as the dynamo, with such modifications as the different conditions of working impose, and start it and excite the field magnets from a continuous current circuit, run with our alternating circuit, supplied with current by a dynamo at the central station. If we wish to distribute 500 h. p. our continuous circuit should have a maximum capacity of about 50 h. p. To start the motor we should have the following arrangement: there should be two breaks in our armature circuit, one between the regular brushes of the machine, the other at a commutator for the continuous current. At this second break the two ends of the circuit should be taken to alternate bars of the commutator, the number of bars being such that the direction of the current is reversed every time a coil passes a pole. The alternate bars are normally connected by a metal ring pressed against them by a spring; in this case we will have the normal circuit just as if there were no continuous current commutator. On the motor would be a switch-board that would accomplish the following things: If we wish to start we turn the handle of the switch to a certan position, this will short circuit our regular brushes and by the aid of a couple of levers will drop the continuous circuit brushes on the commutator, at the same time pulling away our metal ring. The motor will then start as a continuous current motor; when it has reached its proper number of revolutions or is above it, turn the handle a little further; the continuous current brushes will be raised, the metal ring will connect the commutator bars, and the alternating circuit will be made and the motor will continue to run and will do work.

Now, I consider that the advantages of this plan are these: It makes the motor simple and cheap to build; it will be more efficient and have a greater output than the other motors that have been discussed; the currents to excite the fields will have to be supplied anyhow, and they cannot be supplied more economically than from the central station; being simpler there will be less liability of derangement.

The motor described by Professor Thomson that I mentioned above, consists of field magnets through which the alternating current flows, with an armature not in any way connected with the external source of current, but which has currents induced in it just as if it were the secondary of a transformer. The circuits of all of the armature coils are open excepting one that is in such a position that the current induced in it will be repelled by the pole-pieces. In this form I do not think the motor will be particularly efficient or give any considerable output. It is possible that the principle may be further developed to give a considerable output, but I do not believe that any motor in which the field is fed by alternating currents can be cheaply made, although this is a matter of which I have no experience.

To prevent motors stopping when the load is thrown on it would only be necessary to drive the load from a friction pulley on the shaft of the motor. The pulley should

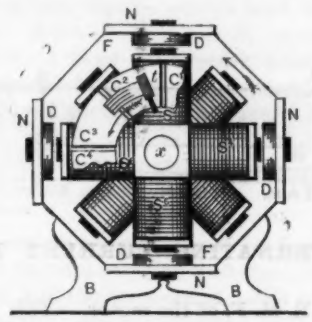


FIG. 10.

be so adjusted that it will turn just before the motor falls behind its point of its maximum work.

It is possible that all of the plans I have suggested have been tried by the different inventors who are at work on this subject. If a motor of each type that I have mentioned were built and proper experiments were tried upon them, we would—provided we had the ability to interpret and apply our results—have the data necessary to design the best possible machine of each type, and if we build these it should settle the question as to which form will be the best. There is no necessity in building an indefinite number of motors to experiment with. It is too much the custom, if we wish to design a dynamo for instance, to build twenty different ones and see which is best. One machine, with proper experiments and deductions, should put us on the right track.

Dr. Holmes once said that when he had written anything that pleased him it immediately seemed very old indeed. I, with humility, feel much the same way, as if what I had said this evening is so apparent that every one must have known it. I can only hope that some of the suggestions I have made will help the development and final successful application of the alternating current motor.

DISCUSSION.

Mr. WOLCOTT: I have been very much interested in Professor Duncan's paper. It throws rather a different light upon the subject of alternating motors from the paper of Mr. Stanley. From the latter paper we concluded that the alternating system, all the way through, was slightly more economical than the direct. But Professor Duncan has shown, I think, pretty conclusively that there are various losses there which we do not have in the direct system. The loss from heat, which depends upon the

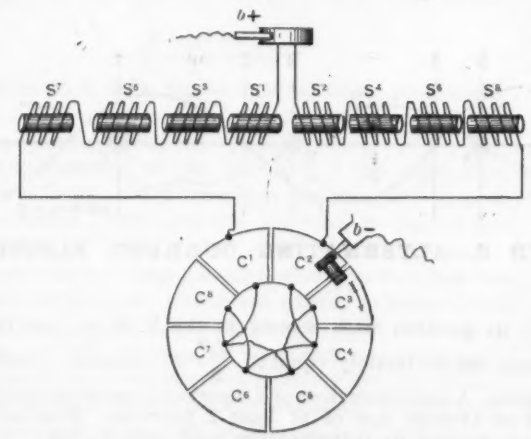


FIG. 21.

square of the current, I think is very neatly demonstrated: The work depending on the product of the current and the electromotive force changing in sign whenever the electromotive force changes, while the loss in heat is constantly plus because the square of the minus quantity is plus, as well as that of the plus quantity. There is one advantage, I think, in the alternating system which is entirely of a practical nature, irrespective of the efficiency, and that is that you do not use any commutator at all. I know one of the greatest practical difficulties in both motors and dynamos is the trouble of having a commutator. If there is any possibility of running a street railway with an alternating motor I think it would be a great advantage, even if it was not so economical.

Mr. MAILLOUX: I would like to remark with reference to the application of alternating currents to the purposes of electrical traction, as my friend Mr. Wolcott suggests, that it will probably be some time before we succeed in utilizing it, however great may be the advantage of its use; because the alternating current motor fails to afford one of the chief requirements demanded in a motor for electrical traction, namely, capacity for producing great torque or effort at the periphery of the armature at the time of starting. This is exactly what the alternating current will not do. Dr. Duncan has pointed out the necessity for gradually putting the load on, so to speak; while, as we know, in electrical traction, it is necessary to develop large pulling capacity or effort.

Mr. CROCKER: There are two or three practical points that suggest themselves to me. In the first place, Dr. Duncan speaks about the great cost of a laminated field, and he speaks of it as if it were practically a bar to the use of laminated fields. If I were going to make a wrought iron field, or if I were bidding for a contract to make wrought iron fields, I would profer to make them laminated rather than of forging or any other form of wrought iron that I have ever come across. So far as I am concerned, I prefer the laminations. I have been experimenting somewhat myself in this direction and was quite pleased with that feature of the alternating current motors, viz., that they *did* involve laminated fields. Then the other point, about the putting on of a load suddenly. That is a difficulty no doubt, and a serious one; but still it does not go on with the mathematical suddenness that Dr. Duncan speaks of, I think. The belt will squeak and the load will gradually come on, and in ordinary cases, where the load is great, but not very great, it will come on gradually, the motor will take it and, I think, will run along with it. Of course, that is a question of degree; in some cases it would, in some cases it would not. But I think you could arrange that by avoiding the introduction of alternating current motors where they had to suddenly take a heavy load, and that would be, of course, a limitation. Then as to the objection that Mr. Mailloux brought up, he spoke merely of one particular kind of alternating current motor, whereas Dr. Duncan enumerated four. I do not remember the classification very well, but I think Mr. Mailloux's objection only applies to one or two of the four classifications. The other two would be entirely outside of Mr. Mailloux's objection.

Lieut. F. J. PATTEN: Dr. Duncan has shown us that the curve of counter-electromotive force has a variable position with respect to the mean, *i. e.*, oscillating from side to side; and I wish to ask whether any such oscillation takes place or not provided the motor is running under a constant load.

Dr. DUNCAN: I think the oscillation certainly would take place no matter what load is on the motor; because in a part of every period—and a period takes place every one three hundredths of a second—the motor is not a motor at all, it is a dynamo. That is, it is absolutely putting current into the main line. The only way to get the energy and throw that current into the main line is by decreasing its speed and drawing from its energy of rotation. Therefore, where it is in those areas it will slow

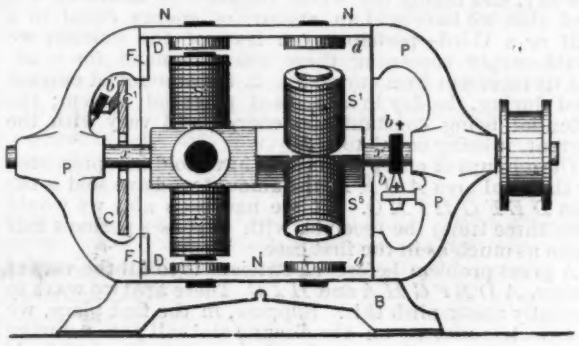


FIG. 11.

down in speed. Where it is in the larger areas it will increase its speed. But the oscillation will occur whether the load is constant or not.

Mr. CROCKER: As regards the regulation of motors and the point that Mr. Mailloux brought out, it happens that one form of alternating current motor that I have been working on lately is particularly well adapted to being regulated. One of the most desirable means of regulation in any motor cannot be used in an ordinary direct current motor, on account of sparking; that is, the shifting of the brushes. When we reverse a motor by shifting the brushes, I mean shifting them right over, at first it would pass through the point of maximum sparking and would create a very serious trouble there, even when we reduce the power. It happens, as I say, that one form of motor works in exactly the other way, and that as you decrease the power you decrease the sparking, and when you reverse it there is no sparking at all. Therefore you can regulate it in that way, which is just the way everyone would like to regulate motors if he could.

Lieutenant PATTEN: I have designed a form and made some elementary tests of a motor of the kind suggested by Prof. Elihu Thomson in his paper read before the Institute last spring. I have always regarded Professor Thomson's motor with a great deal of admiration. It would seem from some of the discussions we have listened to that whatever work we are going to get out of an alternating system must be a question of difference between two factors opposed to each other—the self induction of the circuit and the power generated as well as the heating. Inasmuch as all our results must be due to the difference between the two quantities, I have worked upon that line, trying to give that difference its greatest possible chance to do some work. If you will remember, Professor Thomson's motor as Dr. Duncan has explained it to-night, consists in a fixed field and a revolving armature, the circuit of which was closed when it came into position of action; at that point the circuit is momentarily closed.

Fig. 9 illustrates this principle. *S* is a solenoid with a soft iron core *I*, and *D* is a closed circuit of high self inductive capacity, preferably a copper disc. When alternating currents are sent through the coils of the solenoid *S*, and the centre of the disc *D* is not immediately in the prolongation of the axis of the solenoid, there is a tendency to separate, as indicated by the two arrows. As in all forms of alternate current dynamo-electric machinery the effective effort is always due to a difference between two unequal and opposing actions, so in any machine in which the principle thus described finds application, the rotary torque or moment of rotation will be due only to a difference of two efforts, as shown in the preceding analysis; and the machine here illustrated is a simple mechanical arrangement of parts, the purpose of which is to cause this tangential effort, however small, to work at a possible maximum of advantage. Those who recall the forms of machine illustrated in a former lecture and

based upon this principle will remember a form of machine not differing widely from the ordinary direct current machine. The armature placed at the centre of the machine consisted of a number of coils of high self-inductive capacity, the different circuits of which were closed in succession as they arrived in the position of maximum repulsive action. In the machine I have designed the application of the same principle is reversed with the apparent effect of producing a more continuous rotary effort as well as a greatly increased moment of rotation by virtue of placing the point at which the effort is applied farther from the axis of rotation and thereby giving to the force at work, however small, a much greater lever arm. Figs. 10 and 11 are end and side elevations of the machine, and Fig. 12 is a diagram of circuits and connections. A polygonal frame *F F F* is connected by latteral strips *N N*, and all is supported upon the base *B B*. Secured to the lateral strips *N N* are two sets of copper discs *D D* and *d d*. These discs constitute the armature of the machine; they are arranged peripherally, as shown, fixed to the frame structure, and consist of circuits of high self-inductive capacity that remain permanently closed.

A spindle *x x*, Figs. 10 and 11, carries a revolving switch C^1 C^2, or sunflower, which is secured to the spindle and turns with it. This sunflower commutator constitutes one terminal of the machine, while an insulated ring *b* +, and its contact brush secured to the support *P P*, constitutes the other. Under each set of discs, *D D* and *d d*, and secured to the spindle *x*, is a set of solenoids. Those of one set being placed at an angle of 45 degrees to those of the other set, from which it results that these two sets of solenoids will each come alternately into action with respect to its own set of copper discs. Each set of solenoids has its four coils connected in series and the two sets are arranged in two independent circuits. Both have one terminal secured to the contact *b* +, and the other terminal to the alternate segments of the revolving sunflower. This system of connections is shown in Fig. 12, in which the eight-part commutator is shown with alternate segments connected to each other in separate series. The coils S^1, S^3, S^5, S^7, form one set of revolving solenoids connected in series from the rubbing contact *b* +, which forms one terminal of the machine, to the commutator segment C^1, and thence to all the odd numbered segments. In like manner the other set of solenoids S^2, S^4, S^6, S^8, are similarly connected in series to all the even numbered segments, C^2, C^4, C^6, C^8. From this arrangement it results that, as the spindle revolves, carrying these solenoids as a sort of fly wheel, the alternating current will be sent in rapid succession first through one set of solenoids, and then through the other, and by suitably placing this commutator upon the spindle it can be made to send the current through the different sets of solenoids during the periods of maximum effort of repulsion between each set and its corresponding set of copper discs.

The moment of rotation is evidently a maximum under this system of construction, and by increasing the number of sets of solenoids that follow each other in action, the effort of the rotary torque may be made nearly continuous and constant.

It is evidently not contemplated that this motor shall drive horse cars. Its efficiency is not high, and its form renders such an application quite impossible, but it can find a place in the smaller industries, where light motors fill a definite requirement, and render an alternating current circuit a paying one during the working hours of the day.

Dr. DUNCAN in conclusion replied to some of the points brought up by the various speakers, and his remarks are touched upon on our editorial page.

1874—1888.

With this week's issue THE ELECTRICAL WORLD completes the FOURTEENTH YEAR of its publication.

When one contemplates the present magnitude and importance of the many and varied electrical industries, not only in America, but throughout the civilized world, and then bears in mind that for years after the establishment of this journal there were no electric lights in use, no electric motors, no storage batteries, no telephones even, he gets a realizing idea of the wonderful growth and development of the electrical business during the past decade.

THE ELECTRICAL WORLD, the pioneer electrical journal of America, has literally grown up with the business. It has kept step with the rapid strides in telegraphy, telephony, electric lighting, and the electrical transmission of power. Under the name of *The Operator*, its first number was issued March 1, 1874. At that time it consisted of but four small pages. It was published semi-monthly, and was devoted to telegraphic news and gossip. As it developed, it chronicled, as they arose, the beginnings of the telephone, the electric light, the electric motor and the storage battery, and in this and other ways did what it could to speed the day when electricity shall be in much more general use than at present. Its editor and publisher was one of a party of fifty before whom the public test of Mr. Bell's telephone was made one Sunday during the Centennial Exhibition in Philadelphia, in 1876. There have been few important public tests or exhibitions since that time in any department of electrical research and application at which THE ELECTRICAL WORLD has not been present on behalf of its readers.

No journal is considered to have attained the proper dignity or importance in the newspaper profession that has not been the defendant in a libel suit. While it was still known as *The Operator*, this journal had its libel suit and, as usual, came off with flying colors. A certain so-called telegraph college in Brooklyn was making strenuous efforts to get young men and women to learn telegraphy—or at least to get the fees from the aforesaid young men and women. *The Operator* considered it its duty to point out the true character of the "college," and the result was a letter from a Brooklyn lawyer asking a retraction under pain of a libel suit. The retraction was not published and the libel suit followed. Even more, however, was proved against the "college" than had been charged in the article; and not only was the case dismissed, but the "college" at once disbanded, and no one connected with it, so far as we know, has engaged in the business of teaching telegraphy since.

The paper endeavored to cover the telephone and the electric light as these new departments of electricity came along, but after a while it was found necessary to change the name, in view of its wider scope, and this was done at the beginning of 1883. For a few months, to avoid confusion, the name was THE OPERATOR AND ELECTRICAL WORLD, but this was soon shortened to the present comprehensive title of THE ELECTRICAL WORLD.

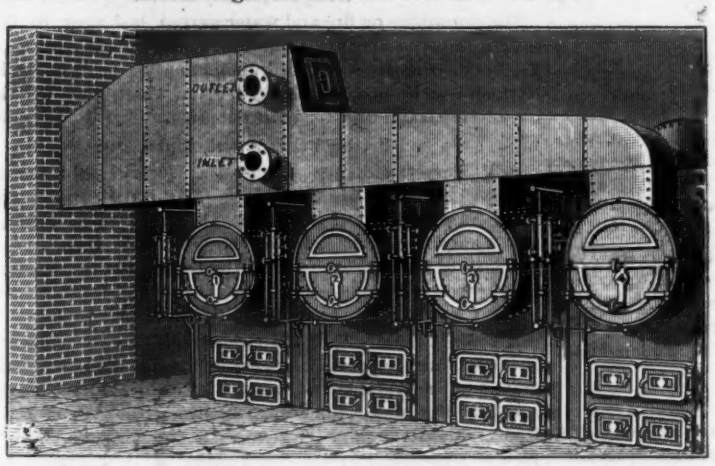
The growth and developement of the paper in recent years is well known to our readers, and we are inclined to be modest, and not to talk too much about our own achievements. If any one, however, will take the trouble to compare THE ELECTRICAL WORLD of to-day with the first issue of the old *Operator*, or with any subsequent issue of either *The Operator* or THE ELECTRICAL WORLD, he will see that not only has the paper increased in size and influence, but that the quality of its contents has also improved in a similar ratio. As was said in these columns some months ago, THE WORLD permits no limitation of its range or sphere of work, but is alive to the development of electricity in every department, and has its readers as well in China as in Africa, and not only in Asia Minor and India, but in every section of North and South America—in short, wherever throughout the world there is interest felt in electrical matters—wherever the telegraph, the telephone, the electric light, the electric motor, the storage battery, or any other kind of electrical apparatus is in use. The universal recognition accorded THE ELECTRICAL WORLD has been won by assiduous and conscientious work, and the position thus gained will be held by the same means that have brought the paper to its present leadership in the field of electrical journalism.

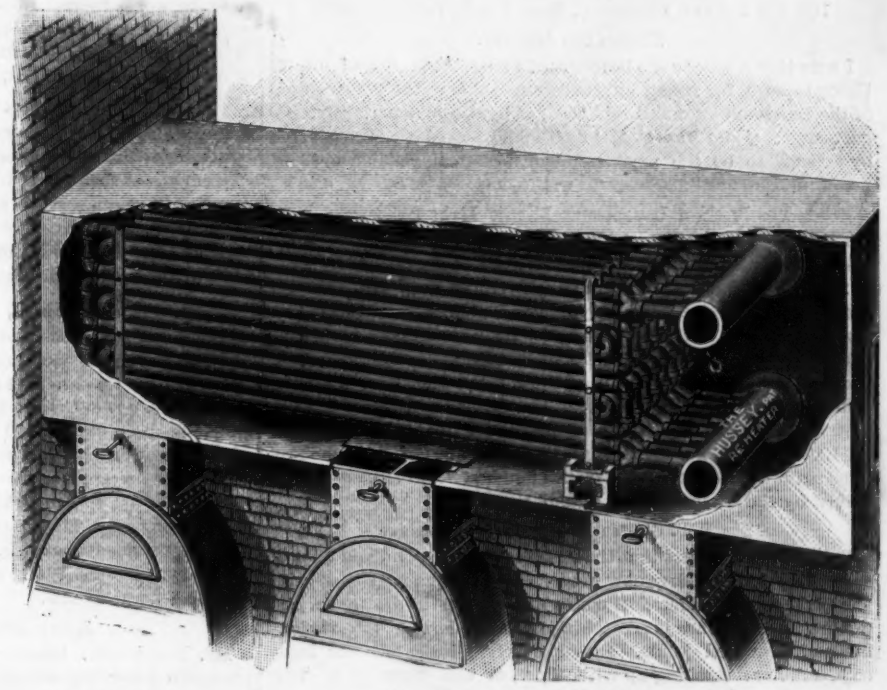
The Hussey Re-Heater for Electric Light Plants.

There is probably no industrial agent in the production and use of which there is more loss and waste, or a wider and more interesting field for the invention and application of devices for economizing cost and increasing efficiency, than is to be found in steam and in the appliances connected with its use; and to-day steam enters more largely into the industrial processes carried on by mankind, and occupies a more important relation to the development of progress in the arts and manufactures, and in the supply of the growing demands of civilization, than any other agent of industry.

Probably the two most important mediums of lost energy to which the use of steam is now subject, and which make the heaviest drafts on the furnace fires, are the waste gases of combustion escaping up the chimney, and the exhaust steam blown away into the air.

The Hussey re-heater has been devised to retain and convert to profitable use the energy hitherto lost through these two avenues, and it has met with considerable success. Its principal applications are to the re-heating of exhaust steam, super-heating of live steam, the heating and circulation of air and the heating of water, and it accomplishes these various results absolutely without cost for fuel, by an ingenious, but simple and practical method of utilizing the heat conveyed in the gases of combustion on their way from the furnace to the chimney.





FIGS. 1 AND 2.—THE HUSSEY RE-HEATER FOR ELECTRIC LIGHT PLANTS.

It is well known that these gases have a temperature in the furnace of from 2,000 to 2,500 degrees, and it is a fact not perhaps so generally known that they carry into the flue, and retain for some distance from the furnace, a temperature of from 400 to 600 degrees.

The Hussey re-heater gathers up and imparts to the exhaust or live steam or air passing through it a temperature within about 50 degrees of the temperature of the gases in the flue, or such proportion thereof as may be desirable for any special purpose, and does this without cost for fuel. The temperature thus imparted by the re-heater to its passing contents can be regulated to any desired extent and perfectly controlled, so that by means of its use uniform temperatures for those processes requiring regularity and uniformity in heat can be accurately maintained.

Exhaust steam leaving the cylinder of an engine at a temperature of about 212 degrees, and saturated with moisture, can be re-heated, highly vaporized, and made dry and elastic, by passing through the re-heater and can then be distributed to any required heights or distances for heating purposes, without any appreciable back pressure on the engine, and in a state to do effective service in heating.

The advantages to be derived from the use of the Hussey system in re-heating live steam will be obvious to all practical steam users or engineers, when it is understood that by means of this device live steam can be superheated to within 50 degrees of the temperature of the flue, without any additional cost, and to any desired temperature above that of the flue with but a very slight additional cost, and, in either case without any increase of the pressure with which it may be convenient to deliver steam from the boiler to the re-heater. Thus, for example, steam may be delivered from the boiler at a pressure of, say, 10 pounds, representing a temperature of about 240 degrees, and superheated by means of the re-heater to say, 300, 350, 400 or 500 degrees as may be desired, without increasing the pressure, while to obtain these temper-

atures in the boiler itself would involve pressures of over 50 pounds, 180 pounds, 235 pounds, and 700 pounds respectively, the last being, of course, impracticable in any form of boiler thus far constructed.

The growth of electric lighting has developed a new and wide field for the use of steam, and given a new importance to the subject of economizing fuel in developing power and heat. Most electric light companies require a much larger amount of steam for power in running their machinery than is necessary for heating their own premises, so that even if their exhaust steam could be used advantageously for their own heating purposes without being reheated, they would still have a large surplus of exhaust to be blown into the air.

If re-heated by the Hussey system, this exhaust steam not only becomes more manageable and effective for their own heating purposes, but the surplus is made available for distribution to neighboring buildings, and may become an important source of revenue. In this view the system would seem to be especially worthy of the attention of electric light companies.

In the accompanying engravings, Fig. 1 represents a part sectional view of the re-heater, the steam passing through the coils shown, around which the hot furnace gases pass. The illustration Fig. 2, shows the manner in which the reheater is applied in the Welles building in this city.

Special Correspondence.

NEW YORK NOTES.

OFFICE OF THE ELECTRICAL WORLD,
168-177 POTTER BUILDING, NEW YORK, Feb. 20, 1888.

Electric Gas Lighting.

I note that a patent has been issued to Mr. A. L. Bogart, of 22 Union Square, for recent improvements made in the construction of the Bartholdi automatic electric gas lighting burner. Mr. Bogart says: "The improved 'Bartholdi' automatic is considered by experts to be the most compact, practical, reliable and best made in existence."

The Brooklyn Incandescent Electric Light Company.

This company, of 292 Graham street, have now 100 lights installed, and supplied from Julien storage batteries. They have a 20,000 watt dynamo set up and running in the Citizens Station, Liberty street, Brooklyn. The Mutual Electric Manufacturing Company are now building for them three more machines, one of 20,000 and two of 60,000 watt capacity. The Brooklyn Incandescent Company are using the cut-out and time switches of the Mutual Company's make. The latter company are completing one of the new Knowles meters for measuring current. At Belvidere, N. Y., the Mutual Company are running a 35 arc-light plant with success. The plant includes two 25-light machines driven by the Diamond Drill automatic engine.

The E. P. Gleason Manufacturing Company.

This company report that their sale of fancy, plain and assorted *electric* shade holders now nearly equals in quantity their output of *gas* shade holders, of which they claim to be the largest producers. They are just catching up to orders on the various kinds of insulated joints. Either nearly all the electric light companies are stocking up with these, or else there is a great boom in incandescent electric lighting. Glass goods are going rapidly, but are not being pushed, in view of the general strike of the glass workers. This company are about to issue a new supplement to their catalogue "E," in which will be found many articles of interest. The first copies will be distributed at the Pittsburgh convention.

An Electric Damper Regulator.

Mr. Charles S. Pattison, electrician and engineer of the very complete electric light plant at Mr. E. H. Johnson's residence at Greenwich, Conn., is enthusiastic in his praise of the new electric damper regulator recently invented by Mr. Johnson, and which Mr. Pattison has now had in use for some little time.

Miscellaneous.

The New York Insulated Wire Company are actively engaged filling large orders for their white gum core Grimshaw wire and cables for the steamers "City of Troy" and the "C. H. Northam." It may not be generally known, that in the Grimshaw white core re-proof wire the compound is covered with asbestos.

Mr. E. Imbauser, 206 Broadway, is still exhibiting the new arc lamp of 1,000 c. p. run from the Lahmeyer dynamo, at 18 Vesey street. I have already alluded to the construction of this lamp, and I may add that it is very steady. I believe Mr. Imhauser thinks of negotiating the sale of the patents on dynamo and lamp for this country.

W. T. H.

NEW ENGLAND NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
48 Congress Street, Boston, Feb. 18, 1888.

Personals.

Mr. Leopold Schlegemilch, president of the Schaefer Electric Manufacturing Company, this city, has fully recovered from his illness. He regrets, however, that he will not be able to attend the Pittsburgh Convention.

Mr. P. H. Alexander, general agent of the Sawyer-Man Electric Company for New England, who found it necessary a few weeks ago to take a Southern trip to recuperate in health and strength, and has been making his temporary home at the St. James Hotel, Jacksonville, Fla., has notified his business asociates that he will return to Boston Feb. 26. Mr. Alexander is now enjoying excellent health.

Mr. B. E. Waters, of the Brockton, Mass., Telephone Exchange, has just made application for letters patent for a device for demagnetizing watches.

Mr. Gardiner C. Sims, of the Armington & Sims Engine Company, Providence, R. I., favored this office with a visit on last Saturday. Mr. Sims is also the president of the Providence Girder Rail Company, the product of which is attracting widespread and favorable attention from street car railroad companies.

The following named Boston gentlemen have signified their intention of attending the Pittsburgh Convention, viz.: H. B. Cram, Treasurer, Bernstein Electric Light Manufacturing Company; F. E. Clark, Treasurer, Campbell Electric Supply Company; H. H. Eustis, Electrician, Eastern Electric Cable Company; A. L. Rohrer and George W. Davenport of the Thomson-Houston Electric Company; S. E. Barton, of the New England Insurance Exchange; Frank Ridlon, Treasurer, Sun Electric Company; Geo. W. Adams, Manager, Boston Electric Protective Association; R. F. Ross and Allan V. Garratt, J. S. Bickford, Louis W. Burnham, Vice-President Electric Gas Lighting Company; C. D. Wainwright, Manager Wainwright Manufacturing Company, and Dr. A. F. Mason, Manager Simplex Electrical Company.

Change in Name of a Wire Product.

I have been requested to announce to the electrical fraternity that wire heretofore known as the "Campbell Line" wire will hereafter be named "The Vulcan" wire.

Not Manufacturing Dynamos.

The Schaefer Electric Manufacturing Company, of Boston, has discontinued the manufacture of dynamos for incandescent electric lighting, as once before announced in my notes. This company has, however, increased its manufacturing facilities in its lamp and incandescent outfit departments, and large orders for the "Schaefer" lamps are being promptly filled daily at the company's Cambridgeport, Mass., factory. President Schlegelmilch reports a large demand for the "Schaefer" lamp from various sections in the west and south as well as along the Atlantic seaboard.

"Shut Down" of an Arc Globe Factory.

A dispatch from Sandwich, Mass., dated Feb. 14, reads as follows: At a meeting of the directors of the Boston & Sandwich Glass Company at Boston yesterday afternoon, it was voted to close the works there. General Manager Spurr ordered the firemen not to put on more coal, and the fires will be allowed to go out. The decorating, cutting, etching and other deparments will be closed on Saturday next.

Supplies for Steam Plants.

Messrs. Charles W. Trainer & Co., dealers in H. W. John's asbestos for steam pipe and boiler covering, at No. 44 Oliver street, Boston, are at the present time doing a very large business in the covering of steam services among our New England mills. This firm has recently moved into its new store, which gives large and increased facilities for business. The high character and integrity of this firm is an ample guarantee for its work.

The Providence, R. I., Girder Rail Company.

A new enterprise has been formed at Providence, R. I., which bids fair to become one of the most popular and wealthy corporations in New England. It has been incorporated under the name of the Providence Girder Rail Company. Its product is a rail which has been in practical use for seven years, and which has a wide reputation for its peculiar merits for use on surface railroads. It has been clearly demonstrated that the girder rail is specially adapted for use on street railroads where electric motors or cables are in operation. The officers of the company are: Mr. Gardiner C. Sims, president, and Mr. Herbert N. Fenner, treasurer and secretary. Messrs. Wm. Wharton, Jr., & Co., of Philadelphia, are the general agents.

A New Primary Battery Solvent.

Mr. Theodore L. Kauffer, No. 51 State street, this city, has perfected a new depolarizer, which, to all appearances, possesses remarkable merits and advantages. Mr. Kauffer has given to his new solvent the name of the "anhydrous battery solvent." It is claimed that it combines all the desirable qualities of the strongest bichromate of potash solution, yet excels the latter in several point, *i. e.*, it is a dry compound; it is adapted for every purpose where carbon batteries are required; it is always ready for use, and needs only the addition of water when placed in a battery jar; it is cheaper and cleaner to handle than any other primary battery solution; it does not throw off injurious fumes or dangerous gases; is not affected by changes of temperature and will not freeze; it does not cause chrome alum to form on zinc or carbon and does not creep up on the electrodes or jar; its action upon the zinc is peculiar, leaving the surface remarkably smooth and even, and more readily re-amalgamated.

Crosby Steam Gage and Valve Company.

The Crosby Steam Gage and Valve Company has recently occupied its fine new factory on Roland street, Boston. It is 125 × 45, with an L which contains the foundry, blacksmith shop and boiler room. There is a room 35 × 40 feet set apart exclusively for the use of the factory employés. It has every convenience for comfort, and is supplied with files of papers devoted to electrical, mechanical and manufacturing affairs. Altogether, the industry is one showing every sign of high organization and prosperity.

W. I. B.

PHILADELPHIA NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
39 South Tenth Street, Philadelphia, Pa., Feb. 18, 1888.

The Philadelphia Electrical Society.

The Entertainment Committee of the Philadelphia Electrical Society announces the following lectures to take place during the month of February: By E. E. Starr, on "The Storage Battery:" M. D. Law, on "The Thomson-Houston Dynamo;" Dr. C. Seiler, on "Electricity in Medicine;" C. M. Knapp, on "Electrical Measurements." Additional lectures are in course of preparation.

J. E. Jeffords & Co.

Among the business houses which form a part of the electrical field is that of J. E. Jeffords & Co., at Lehigh avenue and Talman street, where they have been located for over twenty-five years. This firm do a large portion of the work in this country in the line of porous cups, and that their goods are of the highest character, and give entire satisfaction, is attested by the fact that nearly all of their patrons are of many years' standing. All of their goods are carefully made, thoroughly inspected and have a reputation second to none. They have accumulated during their long experience molds of almost every conceivable style and shape, a large part of their business in this department having been done for laboratory and experimental purposes. Their new price-list mentions nearly one hundred different sizes and shapes of porous cells, in addition to the large amount of work done by them on orders for unusual or irregular designs. They report a good spring trade, although they have made no special effort to increase their business.

Electro-Pneumatic Transportation.

A special dispatch from Baltimore, dated the 13th, says: A company was incorporated in this city to-day which proposes to send merchandise and mail matter by electro-automatic power over an elevated railway, the cars on which cannot run off, and are to make the time of transit from Baltimore to Washington ten minutes. Some very prominent business men and capitalists have engaged in the enterprise.

E.

WESTERN NOTES.

BRANCH OFFICE OF THE ELECTRICAL WORLD,
44 Lakeside Building, Chicago, Feb. 18, 1888.

Sun Electric Light.

The passage of the Sun electric light ordinance was agreed to last week by the South Side Committee on Street and Alleys. The franchise of the Sun Company extends from Adams to Twenty-second street, between the lake and river. It agrees to furnish one street light of 2,000 candle-power at each street intersection at absolute cost, which is to be determined by the Controller, and besides it is to pay 2½ per cent of its gross earnings into the city treasury.

A New Corporation.

A license of incorporation was issued on Feb. 11 to the West Chicago Rapid Transit Company, capital stock $6,000,000; object to construct, maintain, lease, or acquire and operate elevated railways in Chicago, on Lake, Randolph, and Van Buren streets, from the lake the entire length west on such streets, and on Milwaukee, Ogden, and Blue Island avenues, Halsted street, and other parallel and cross streets; incorporators, John D. Jennings, E. Nelson Blake, and Abner M. Wright.

The Meigs System.

It is reported that the Directors of the Lake Street Elevated Railway met last week and virtually decided to adopt the Meigs system.

Doings of the City Council.

The committee on fire and water agreed last week to the passage of the ordinances of both the Cushman and the Interstate Telephone companies. The ordinances were sent to the law department to be properly drafted, after which they will be sent back to the committee for their adoption.

Uniting Public Electric Light Plants.

Prof. Barrett proposes to unite the electric light plant of the county building with that of the City Hall. The *Tribune*, in commenting upon it, says that "it ought to be acccepted by the County Board, as it is in the interest of economy. It will also lead to the improvement of the service in the county building."

An Improved Grate Bar.

Mr. W. H. Lahman, of 154 Lake street, Chicago, manufacturer of the Lahman improved Kirkwood patent shaking and dumping grate bar, reports that the demand for his specialty is unusually good for this, one of the dullest months of the year in the trade. He has recently greatly improved the old Kirkwood bar with a view to adapting it to the consumption of low grades of fuel, such as screenings, pea coal, etc. He publishes a very handsome pamphlet giving an illustrated description of his bar, with a long list of well-known public buildings, establishments, electric light plants, etc., where the bar is now in use. This pamphlet he will be happy to furnish to any one on application.

The Electrical Supply Company.

The Electrical Supply Company have just issued a new catalogue descriptive of electric light construction material manufactured and for sale by them. The catalogue contains new cuts and is handsome.

Matchless Metal Polish.

Last week I called on the Matchless Metal Polish Company, manufacturers of the well-known Matchless metal polish and "Tripoline," and found them very busy filling orders. Among orders just received was the second order from La Grange, Oregon, for 100 pounds of "Tripoline," to be used on engines; also, besides a large number of large orders received from electric light plants throughout the country, was one for the United States Army.

The Van Depoele Company.

The Van Depoele Company are putting in a 60 arc-light plant at Helena, Ark. They have also contracted to put in a 100-arc light plant for the Long Island Electric Company, Brooklyn, N. Y. Their electric railway at Lima, O., is to be increased by a mile of new track and the addition of three motors. At Scranton, Pa., the electric road is to have four new electric cars of a new and special design, made at the Pullman works, and each will be equipped with a 25 h. p. Van Depoele motor.

Thomson-Houston Company.

The Western department of this company report, among recent orders, the sale of a 50-light dynamo which is to increase the plant at West Bay City, Mich. They have also contracted to supply Fort Scott, Kan., with 1,000 incandescent lights. At Colorado Springs they will add a fifty lighter. The new carbon factory at Fremont, Ohio, built by the Thomson-Houston Company for the purpose of making carbons for their own use, has just commenced operations. The staff at the Thomson-Houston office were made happy last week by their first installment of carbon. The prospects are that the new factory will be kept pretty busy.

Topeka, Kan.

A Topeka correspondent writes us as follows:

The committee appointed by the city council to investigate the various systems of electric lighting visited various cities, and included in the examination the systems of the Thom-

son-Houston, Brush, Fort Wayne, American and Jenney of Indianapolis, and arrived at the conclusion that what is known as the low tension plan is far superior to the high tension plan, on account of evenness and penetration.

They also report that the operating of plants by cities is meeting with increasing favor, the saving in the course of five or six years amounting to a sufficient sum to cover the cost of the plant and operating expenses. After some discussion the council awarded the contract for the construction and operation of an electric light plant of 120 arc lights of 2,000 candle-power to the Jenney Electric Light Company of Indianapolis, and instructed the Mayor to enter into a contract in writing with that company.

Mr. Force Bain

has just completed a cloth cutting machine of very novel design. The knife is operated by a small motor attached, and it is estimated that it will cut forty or fifty suits at one time.

Grand Rapids, Mich.

It is thought that the Edison plant at this place will be in operation in about six weeks.

Detroit.

A correspondent states that a company is to put in a storage plant which will operate 5,000] incandescent lights. It is estimated that a maximum of 150 horse-power will only be required to operate the plant.

Jackson, Mich.

A correspondent states that a company in this place are furnishing the city with lights at $5 per lamp, per month.

E. L. P.

ENGLISH NOTES.

LONDON, Feb. 1, 1888.

The Cost of Safe Lightning Conductors.

At the meeting of the Physical Society on Saturday Prof. Sylvanus Thompson read a paper on the "Price of the Factor of Safety of Lightning Conductors." He explained that under this title he referred to the prices which would have to be paid for lightning conductors of different metals, so proportioned that they would all afford the same degree of safety to the buildings upon which they were placed. To this end he was of opinion that it was necessary to take into consideration not merely the sectional area of the conductor and the specific resistance of the metal, but also its temperature of fusion. Of two conductors equally good in every other respect, that one was clearly the best whose point of fusion was highest. It may here be remarked that the professor omitted from his calculations the factor of self-induction, and under these conditions some remarkable results were arrived at. It was shown, for instance, that supposing we had a copper conductor costing £100 it might, *with equal safety*, be replaced by an iron conductor costing only £21. If, however, we preferred to use lead, an expenditure of no less than £620 would be necessary in order to obtain the same degree of protection. As for platinum, it is evident that this metal will not be in great demand for the purpose in view of its relative cost amounting to £1,614,278. In the discussion Professor Ayrton expressed the opinion that had self induction been taken into consideration, as it certainly ought to have been, the relative position of iron and copper would have been reversed, and seeing the greater liability to corrosion of iron conductors he did not think it wise to recommend their use. Moreover, he did not feel at all convinced that the question of fusion really came into the matter at all. He certainly could not recollect any case in which a conductor properly connected with the ground has been fused by a discharge of lightning.

Government Control of the Telephone.

The announcement made by the Postmaster-General at Wolverhampton, on Saturday last, that the government contemplated buying up the telephone companies, has naturally created the greatest excitement in telephone circles. The exact words used by Mr. Raikes were, that "before long the system must be taken up by the government, and the telephone placed upon the same footing as the telegraph." In many quarters this is taken to mean nothing more or less than the introduction of a telephone purchase bill in the forthcoming session of Parliament, but it is highly improbable that the actual transfer will take place until the expiration of the Bell patent, in 1890. Be this as it may, the announcement was followed by a sharp rise in telephone stock, and for a time these shares formed the centre of interest upon Change. The provincial companies, especially the West of England and South Wales, came in also for a large share of attention. It is felt, however, that this casual way of making so important an announcement is calculated to do more harm than good unless followed at an early date by something of a more definite character. The tendency will be to hamper the companies in the estimation of the public in the various schemes for extension which they have in hand, while they will, at the same time, be feverishly anxious to push them on. In view, moreover, of the admittedly bad bargain which the Post-Office made in purchasing the telegraph, it is thought by some people that the government will take advantage of the decisions already obtained in the law courts, to the effect that "the telephone is a telegraph." Your readers are probably aware that, in virtue of these decisions the Post-Office already exacts a royalty of 10 per cent. of the *gross* revenue of the telephone companies, except only that derived from private lines. But whatever stress may be laid, or may be attempted to be laid, upon this point, it is clear that the "deal" will be a very big one. In London, owing to the inefficiency of the present service, the scheme is certain to be popular, though it is quite probable that it will meet with opposition in the provinces.

The Discussion of Safety Fuses.

In the discussion on safety fuses which took place at the meeting of the Society of Telegraph Engineers last week, Mr. Crooks described a very ingenious form of cut-out which may interest your readers. It consisted of an electro-magnet having an armature made of a very thin piece of nickel which was held down by a magnet against the tension of an opposing spring. The current at the same time passes through the nickel strip. If, therefore, the temperature of the strip rises above 300 degress C. the nickel loses its magnetic power and is pulled back by the spring, thus breaking the circuit. The advantage of this arrangement is that the cut-out can be so easily replaced in its working position. The instrument has never been introduced on a commercial scale, and, as a mercury contact would be necessary, it has perhaps no practical advantage over other well-known forms of electro-magnetic cut-outs. Mr. Crompton took the opportunity to enter a vigorous protest against the regulation of the fire insurance fuses which require the use of incombustible bases for fuses and switches. He expresses a very strong preference for the use of hard wood, either box wood or beech. China covers or base plates are very apt to be broken, while slate had by no means so high an insulation resistance as was usually supposed. He instanced a case in which the insulation resistance of a large installation fell from 12,000 ohms to 600 when a slate switch-board was substituted for one of wood. Mr. Esson and Mr. Mordey each fully indorsed Mr. Crompton's views on these points, the former remarking that more nonsense had been talked about the fire risks of electric lighting than on any other subject in the world. Mr. Mordey finds that by boiling slate for a long time in paraffine wax its insulation can be largely increased.

The Anglo-American Telegraph Company.

The approaching yearly meeting of the shareholders of the Anglo-American Telegraph Company is looked forward to in the hope of some communication from the chairman on the subject of the Atlantic cable tariff. It is now regarded as practically certain that an early compromise will be arrived at. The only question for discussion is whether the tariffs will be fixed at a shilling, fifteen pence, or twenty pence, per word. According to a correspondent of the *Statist* a 15 penny rate would be 4 per cent. on the ordinary stock of the Anglo-American Company, 6 per cent. on preference, and 2 per cent. on deferred shares, while a twenty penny rate would yield 6 per cent. all round.

Mr. Oliver Heaviside's Electrical Theories.

I do not know whether your readers take any great interest in the somewhat abstruse calculations on electrical theory for which Mr. Oliver Heaviside is so famous, but in any case there are some conclusions of his in an article in this month's *Philosophical Magazine* which will perhaps, in the long future, be regarded as of the utmost practical importance. In long distance telephony, contrary to the usual idea, Mr. Heaviside asserts (and offers mathematical proof of the assertion) that self induction is no foe to the transmission of articulate speech over long wires. He says: "It seems to be imagined that self induction is harmful to long distance telephony; the precise contrary is the case, it is the very life and soul of it." Mr. Heaviside shows that it is merely the resistance of the wire which produces the distortion of the current waves, while self induction positively assists to maintain their true shape. Amongst other paradoxical contents of this paper is a parenthetical allusion to the fact that, for anything we know to the contrary, the true speed of electricity in a wire conveying a current may not exceed one inch an hour. The author also introduces us to a conductor "having a time-constant of one fortnight." But I must refer your readers to the paper itself for a full discussion of these interesting questions.

Secondary Batteries in Central Stations.

A determined attempt is being made in this country by the aid of the daily press to induce the public to believe that the employment of secondary batteries is absolutely essential in the scheme of central station distribution. Dr. Fleming has, however, written to the *Pall Mall Gazette* calling attention to American experience in this matter, and particularly to the Edison central station in New York as an example of five years continuous running without stoppage.

THE TELEGRAPH.

Mexican Telegraph Company.—The annual statement of the Mexican Telegraph Company for 1887 is an excellent one showing 14.4 per cent. earned on the outstanding capital.

Tickers on the Exchange.—The suit of the Consolidated Stock and Petroleum Exchange against the New York Stock Exchange to prevent the latter from removing the Commercial Telegraph Company's tickers, has been in course of hearing before Justice Brown, in the Supreme Court, Brooklyn, and the evidence is now all in.

Bucket Shops in Full Blast Again.—Despite the fact that the proprietors of the bucket shops along Broadway and New street, this city, are held under bail for trial at the General Sessions, all of them are open for business again. There is a smaller attendance than usual, however; yet the quotations are regularly posted on the board, and are closely watched by those who occupy chairs in the "customers' room."

The Telegraph Question.—A special dispatch of Feb. 13 from Washington says: The committee on commerce has failed so far to act on Mr. Glover's bill to regulate telegraph tolls through the Interstate Commerce Commission. Mr. Spooner's bill will be introduced in the House to-day, changed so as to give the Postmaster-General power in the premises. This will make possible a reference to the post-office committee, and it is expected a prompt report will follow.

THE TELEPHONE.

Erie Subscribers.—The Erie Company had 10,388 subscribers in the quarter ending Dec. 31.

Telephone Dividends.—On Feb. 16 the New England Telephone Company dividend of $87,500 was payable, and that of $36,000 of the Erie Company.

Poughkeepsie, N. Y.—The construction gangs employed by the American Telegraph and Telephone Company have been at work on the long distance lines between New York and Albany all winter, and the line is now all up as far as north of Troy.

Rochester, N. Y.—It is reported that the Brown telephone, of which a description has been published in this paper, is now being tested at Rochester, where the company exploiting offers to organize exchanges on the subscription basis of from $25 to $30 a year.

Salem, Mass.—A special dispatch of Feb. 12, from Salem, makes an interesting note of the fact that just eleven years ago that evening Professor Bell made there his first practical test of the telephone by talking to Boston over Western Union wires. The Salem Exchange has now 410 subscribers, 444 miles of wire, and employs 14 people.

Another Inventor of the Telephone.—A special dispatch from Keene, N. H., mentions the death there of Mr. Edward Farrar, one of the leading officials of that place. He had local fame as being "the inventor of the first rude telephone. From extreme modesty he never pushed his claim."

Erie.—The statement that the Erie Telephone Co. must put its wires underground in Cleveland at an expense of $150,000 is officially denied. The facts are that the company has secured an ordinance at its own solicitation to place its wires in the central part of the city underground, as has been done in Boston, believing it to be to its advantage to do so, thereby greatly improving its plant and service and lessening the expense of repairs. The work will be done gradually within the next two or three years, as it becomes necessary to reconstruct lines in the locality mentioned, and $20,000 will cover the entire outlay.—*Boston Herald.*

THE ELECTRIC LIGHT.

Marshville, Wis., is to have the electric light.

Bellaire, Va.—An electric lighting franchise for Bellaire has been asked for.

Farmville, Va.—The city council has the electric light question under consideration,

Henderson, N. C., will have a Thomson-Houston plant put in by Ruffin & Ballou, contractors, of Danville, Va.

Tyler, Tex.—The Westinghouse 1,500-light plant of the Tyler Electric Light Company is to be in operation by April 15.

South Pittsburgh, Tenn.—The Perry Stove Manufacturing Company are putting electric light machinery in their works.

Chestertown, Md.—The Chestertown Water Company proposes to put in an electric light plant. Mr. C. F. Westcott is president.

New Orleans, La.—The local Edison Company has been increasing its plant, and will hold a meeting March 5 to decide as to increasing its stock.

Oxford, N. C.—A contract has been made with Ruffin & Ballou, of Danville, Va., for a Thomson-Houston plant, which is to be in operation by April 15.

Tarrytown, N. Y.—The Excelsior Electric Light Company, of Tarrytown, has announced its insolvency, and it is reported that the station will shortly be shut down.

Tonawanda, N. Y.—The Tonawanda Electric Light Company has been organized by C. Schwinger, M. Reisterer, A. C. Kent and others, with a capital stock of $15,000.

And Electric Blue Paint.—The painter who works by electric illumination naturally prefers the Brush light. Noah, we believe, stuck to the arc for quite a while.—*Boston Bulletin.*

Ellicott City, Md.—A bill is before the legislature to incorporate the Enterprise Illuminating Company, with J. W. Cone, of Baltimore, and others, as incorporators, to build either an electric light plant or gas works.

Boston, Mass.—A certificate of organization has been filed by the Boston Electric Light Company to supply electric light, heat and power. The president is Edward W. Burdett, and the treasurer Benjamin W. Cutler. The same and Charles A. Snow are the directors. The capital stock is $1,000,000.

New Orleans, La.—The injunction obtained by the New Orleans Gaslight Company stopping the erection of the Star iron towers in that city has been removed, the writ now being refused; and work is proceeding on the towers. Col. Flad, of St. Louis, claims the idea as his, however, and says that Mr. M. J. Hart is infringing his patents in carrying out the plans of the New Orleans Tower Company.

Marshall, Tex.—Writing to the *Manufacturers' Record*, from Marshall, Tex., Mr. C. A. Murray says: "I have formed a syndicate for the purpose of putting in electric light plants at five or six points in the State. Two companies under way at present are as follows· Greenville, Texas, a 650-light Westinghouse alternating incandescent plant, and at Marshall, Texas, a 650-light Westinghouse alternating incandescent plant."

The Thomson-Houston in the South.—At Charlotte, N. C., a Thomson-Houston incandescent plant of 800 lights has been installed. At Atlanta, Ga., a plant of 800 incandescents now running in connection with that of 125 Thomson-Houston arc lights. The company are going to build a new station with a capacity of 600 arcs, and will supply the city with 58 more, making 100 for city purposes. Thomson-Houston plants are also going in at Oxford and Henderson, N. C.

Edison Lights in Brooklyn.—Mr. F. R. Chinnock, Brooklyn and New York agent of the Edison United Manufacturing Company, with office in the Garfield Building, Brooklyn, has just received an order for a 600 light plant for large new knitting mills there. This will be a model installation and will include two Sprague motors for running elevators. Mr. Chinnock, it is said, has organized a local Edison company at Rutherford, N. J., on a cash basis, with the stock all subscribed for. It will take 1,100 lamps.

The American System.—In order to facilitate its operation, the American Electric Manufacturing Company becomes in fact, as it is in name, a manufacturer only of electric light apparatus. The other part of its business in the installation of plants, etc., has been turned over to the American Electric Construction Company, of New York, which has concluded a contract with it to buy its entire output of electrical apparatus for the United States except New England, paying cash for the same, and conducting sales, collections, construction and general business on its own responsibility. A similar company is to be organized for New England, and others, it is said, for Canada, Europe, Mexico and South America.

Topeka, Kan.—There has been very active competition for the electric light contract at Topeka, and the award has now been made to the Jenney Electric Light Company, of Indianapolis, for the construction and operation of a plant of 120 arc lights of 2,000 candle-power each. The committee appointed to investigate the subject visited Kansas City, St. Louis, Terre Haute,

Indianapolis, Columbus and Madison, Ind., and arrived at the conclusion that it would be best for the city to buy the Jenney plant, and to operate it in its own behalf. The bids for the plant ranged from $23,000 to $27,000. The offer of the Jenney Company was for a figure approximating the higher limit, and guaranteed that the entire cost of supplies, ordinary repairs and operating the 120 lights should not exceed $6 per light per month, or in the case of all night lighting for every night in the year, $8 per light per month.

APPLICATIONS OF POWER.

Thomson-Houston Motors.—The Thomson-Houston Company report a gratifying increase of business in their motor department. Since the beginning of the present year, beside replacing several steam plants, their motors have been successfully installed in the place of a gas engine, water motor, oil engine and three other makes of electric motors. The gas engine, of nominally 7 h. p., was replaced by a 5 h. p. motor which, beside running the same shafting and machinery, lifts 250 lbs. more on the elevator at the same speed. Mr. H. C. Spaulding, the Eastern representative of this department, is meeting with success in Providence, R. I., where a special motor circuit is operated in connection with the Narragansett Electric Light Company's plant.

PERSONALS.

Mr. D. H. Lauderback has just accepted the presidency of the Chicago Edison Company.

Mr. George G. Ward, general manager of the Commercial Cable Company, sailed for England last Saturday on the 'Etruria" on business of his company.

MISCELLANEOUS NOTES.

Virginia.—It is proposed to form the Virginia Underground Electrical Conduit Company, with a capital stock of not less than $10,000 and not more than $200,000. The incorporators are A. Pizzini, A. L. Wilkinson and others.

Electro-Automatic Express.—The Electro-Automatic Transit Company has been organized at Baltimore for the development of an electric rapid transit system for express and mail business. It is claimed that packages can be sent from New York to San Francisco in 9 hours. The officers of the new company are: B. F. Gambrill, president; T. W. Johnson, vice-president; W. B. Pegram, secretary; A. Brown, treasurer; D. G. Weems, general manager and electrician; J. N. Steele, counsel. The board of directors consists of the above, and J. J. Chisholm, E. B. Bruce, E. F. Abell, W. Whitridge, R. Taylor, S. E. George and F. Brown. Before building the San Francisco line, some experimental tests will be made.

BUSINESS NOTICES.

Trinidad Line Wire, manufactured by the Callender Insulating and Waterproofing Company, is rapidly increasing in popularity. It is a superior article, and meets the demand for all out door uses.

The Pittsburgh Engine.—The house of James Rees, of Pittsburgh, Pa., has lately remodeled its large works, and is now manufacturing the Pittsburgh automatic engine in addition to rolling mill engines, mining machinery, etc.

Jordan & Gottfried, 208 Canal St., N. Y., carry a complete stock of iron and brass machine and wood screws, bolt cap and set screws, taps, dies, files, twist drills, brass and rubber tubing, rod and sheet copper, brass, German silver, steel and iron wire, shafting, tools, etc.

Purchase of Plant.—James A. Taylor & Co., of Wilmington, Del., issue the following notice:

The American Standard Gauge and Tool Works have purchased the plant and business for gauge making from the Betts Machine Company, of Wilmington, Del., and will continue the business in the same place.

Johnston's Patent Agency in New Quarters.—The agency has recently moved across the hall into Room 195, Potter Building, in order to find better accommodations for its growing business. Friends of the agency are cordially invited to visit its new quarters and all are free to avail themselves of its books of reference and other facilities, which are now more accessible than they have been heretofore.

Rawhide Belting.—The Chicago Rawhide Manufacturing Company are the only manufacturers of rawhide belting in the United States. A belt is now being put on the market by the company made with special reference to the requirements of running dynamo machinery. The claim made for it by the manufacturers is that it is pliable and has no stretch beyond the proper elasticity; besides that, they claim that on account of its having extreme adhesive qualities it can be run much slacker, which is very desirable, as it causes less friction and strain on the bearings of the dynamo.

Hine & Robertson, 45 Cortlandt street, N. Y., are pursuing a novel method of inducing electric light companies to try "Eureka" Packing. To every new customer ordering direct from them 15 pounds or more at regular price, 75 cents per pound, they will send a handsome 8-day calendar clock, 12 in. dial, 24 in. high, or a set of brass oilers and tray, 6 pieces, the best made. This is an easy way to secure one of these necessary articles and at same time get a packing indorsed by very many prominent electric light plants.

The Buckeye Automatic Cut-Off Engine.—The Buckeye Engine Company, of Salem, O., issue two excellent catalogues in regard to their well known engine. The first part gives details about the engine. The second part is a most admirable treatise on the indicator, its use and management, and includes also a variety of valuable data on steam and steam power plants. We are glad to see engine builders doing such scientific work. It is a plain indication of a thorough appreciation of all the essentials to a good engine, and does much in the way of diffusing accurate ideas and information on subjects more or less abstruse.

Ireson Leather Link Belting.—Mr. C. L. Ireson, 97 High street, Boston, received the first award for leather link belting at the recent fair of the Massachusetts Charitable Mechanics' Association. His business has increased from July to December over 700 per cent. He has confined his attention to electric light plants, in which the belting is meeting with great success. In his own vicinity he reports recent sales to the Edison Company of Boston, the Boston Electric Light Company, the Somerville Electric Light Company, the Citizens' Electric Light Company of East Boston, the Suburban Electrical Light Company of Brookline, and the Cambridge Electric Light Company. In the last named instance the belt is conveying over 250 h. p. The above is sufficient to show the keen appreciation of the belt in its own locality.

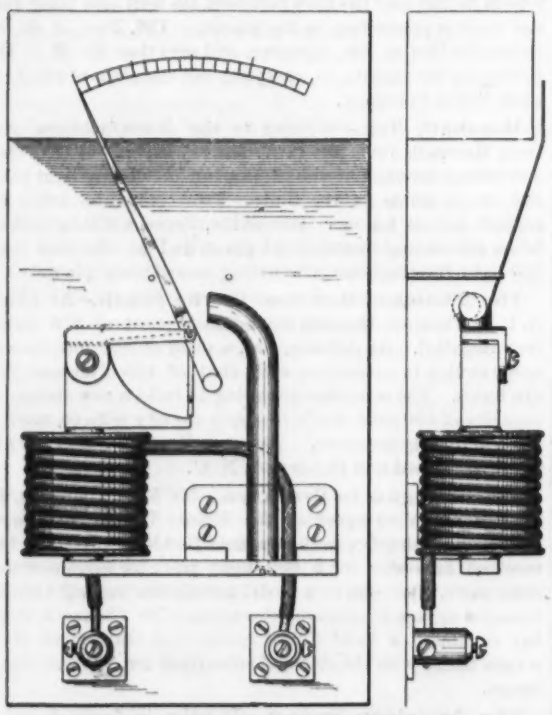
OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

PATENTS DATED FEBRUARY 14, 1888

377,742. Lightning Rod Attachment for Windmills; Eugene O. Daniels, Springfield, O. Application filed Aug. 25, 1887. The invention is designed to provide means for securing a constant yielding electrical contact between that part of the lighting rod which is secured to the movable portion of the mill and that attached to the stationary portion. The contact is made between a conducting annular track and a contact wheel.

377,745. Galvanic Battery; Theodore M. Foote, Boston, Mass., Assignor of fifty-one one-hundredths to Samuel T. Holmes, same place. Application filed July 6, 1887. The inner cup contains sulphuric acid and has a water space about it, the zinc being placed in the water space. Outside of this is the carbon and a bichromate of potash solution surrounding the carbon.

377,763. Printing Telegraph; Jacob H. Linville, Philadelphia, Pa., Application filed Aug. 18, 1887. The invention relates to the peculiar construction of a table of contacts or sunflowers to a novel arrangement of switching circuits; to



378,029. ELECTRIC CURRENT INDICATOR.

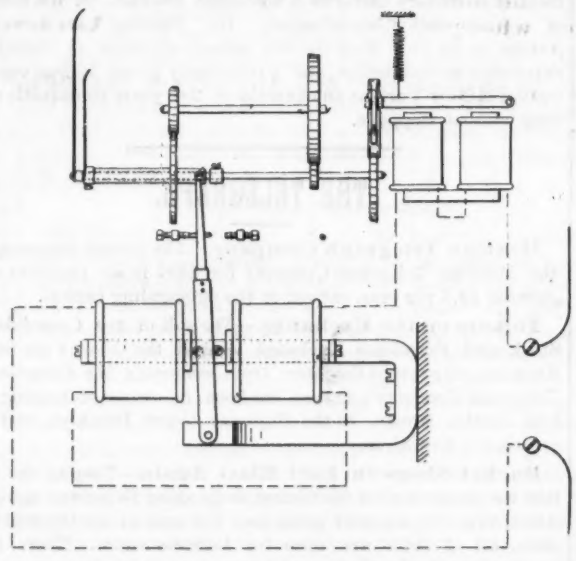
automatic unison devices; to speeed regulating mechanism; to guards inclosing the faces of the type wheels; to signaling devices; to individualizing instruments connected in series for the special purposes of the particular instrument covered by the invention, and to means for rendering the actuating parts plainly visible and accessible, and also for placing the paper in a position where it can be conveniently inspected and manipulated.

377,788. Telephone System; Edward P. Trayer and George H. Kugler, New York, N. Y. Application filed March 17, 1887. A subscriber's plug is carried by the operating lever of a switch, one of whose terminals is connected with the main line, including the subscriber's instruments, and the other with a test wire.

377,862. Combined Telegraph Key and Sounder; Bartholomew Oehmen, New York, N. Y., Assignor to the New Haven Clock Company, same place. Application filed Oct. 13, 1887. The invention relates to structural details.

377,872. Electro-Medical Apparatus; Theodore R. Ten Broeck, New York, N. Y., Assignor to the Galvano Faradic Manufacturing Company, same place. Application filed July 23, 1887. The circuit maker and breaker usually employed in this kind of apparatus is in the present invention included in a shunt around the working circuit.

377,879. Telegraphy; Clement Ader, Paris, France. Application filed July 1, 1887. Patented in England, May 18, 1887, No. 7,265. The first claim describes the invention. "The recep-



377,895. SECONDARY ELECTRIC CLOCK.

tion of electric signals by subdividing the electric current into pulsations succeeding one another at a constant velocity which corresponds to the vibrations of an audible note, and passing the subdivided current through a telephone receiver, thereby producing in the latter a sound of uniform pitch, the intensity of which varies according to the undulations of the subdivided current, whereby the electric signals are acoustically translated."

377,884. Current Regulator for Dynamo-Electric Machines; Walter A. Crowdus and Henry M. Sutton, Dallas, Texas. Application filed Dec. 14, 1886. An iron rod or bar provided with a piston-head is placed within a cylindrical cavity in the field magnet, thereby acting as a dash-pot. These elements are combined with a rotating brush carrier and a retractile spring acting on the rod. Gears connect the rod to the brush carrier, so as to convert the sliding motion of the rod into rotary motion at the carrier.

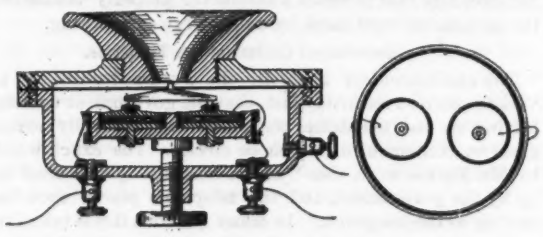
377,895. Secondary Electric Clock; Wirt B. Harvey, Memphis, Tenn. Application filed Aug. 25, 1885. The invention consists in providing a secondary electric clock with a polarized relay in combination with pins so placed with relation to each other, and to the arbors carrying the hands, that the relay armature will be in position to arrest either of said pins at any time for synchronizing purposes. The polarized relay and the usual electro magnet for operating the hands are in the same circuit. See illustration.

377,916. Electric Bell; Jacob P. Tirrell, Somerville, Mass., Assignor to the Electric Gas-Lighting Company, Portland, Me. Application filed Feb. 23, 1887. To facilitate the adjustment of the armature and its supporting spring, an adjusting screw is provided which engages with the projecting end of this spring, and a retaining screw is made to work in the adjusting screw. By these means the supporting spring can be adjusted and held firmly in adjustment.

377,994. System of Electrical Conversion; Edward N. Dickerson, Jr., New York, N. Y. Application filed July 22, 1887. The invention relates to a system by which a non-reversing high tension electric current may be converted into a low-tension reversing current at the point where it is desired to employ it. A converter is combined with a reversing motor which controls the polarity of the main circuit. See illustration.

(1) 377,996. Dynamo-Electric Machine; (2) 377,997. Frame for Winding Armature Coils; Rudolf Eickemeyer, Yonkers, N. Y. Applications filed respectively May 11, 1887, and Dec. 31, 1887. (1) The objects of the invention are to reduce the crossing of wire in each coil at the ends of the armatures; to avoid close contacts wherever the path of any portion of the wire is angular to that of any other portion, and to enable all of the conducting coils or windings to be readily removed from the armature, and to keep each practically intact for ready replacement. (2) This invention is a complement to the preceding, being concerned with a frame for winding coils as described above.

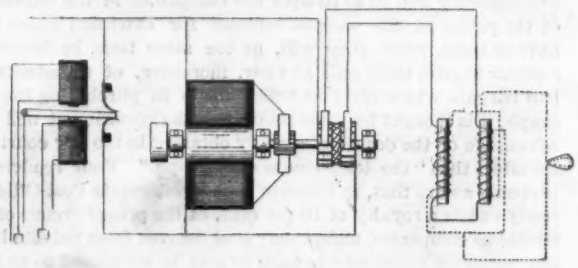
378,021. Underground Electrical Conduit; Robert F. Silliman, Troy, N. Y. Application filed May 23, 1887. An inclosing pipe or cable-case is made in sections adapted to connect at the ends by bolts and flanges. The sections are filled with insulating material, which projects at one end of each section and is flush at the other end. A washer is arranged around



378,044. TELEPHONE TRANSMITTER.

the projecting insulating material and between the flanges at adjacent ends of the sections.

(1) 378,029. Electric Current Indicator; (2) 378,030. Telephone Exchange Central Office Connection; Ernest P. Warner, Chicago, Ill. Assignor to the Western Electric Co., same place. Applications filed respectively March 21, 1887, and Nov. 17, 1887. (1) This is an ammeter consisting of an electro-magnet with its poles extended so as nearly to meet an armature carrying a pointer suspended between the poles. The position of the armature and of one of the poles is adjustable so that the instrument may be set to indicate



377,994. SYSTEM OF ELECTRICAL CONVERSION.

on a graduated scale the current strength. See illustration. (2) The switchman's telephone is placed in a ground branch permanently connected with the back contact strips of the usual cam-lever switches. The test battery remains in circut between the back and the front strips of these switches. By this arrangement the ground-plates heretofore connected with metallic heels on the plugs are dispensed with.

378,044. Telephone Transmitter; Thomas A. Edison, Menlo Park, N. J. Application filed Oct. 14, 1885. This is a multiple transmitter in which two or more sets of electrodes are supported by a common carrier mounted on, and turning with, a central adjusting screw. A turning yoke connected centrally with the diaphragm bears on the electrodes. See illustration.

Copies of the specifications and drawings complete of any of the patents mentioned in this record—or of any other patents issued since 1866—can be had from this office for 25 cents. Give the date and number of patent desired, and address Johnston's Patent Agency, Potter Building, New York.